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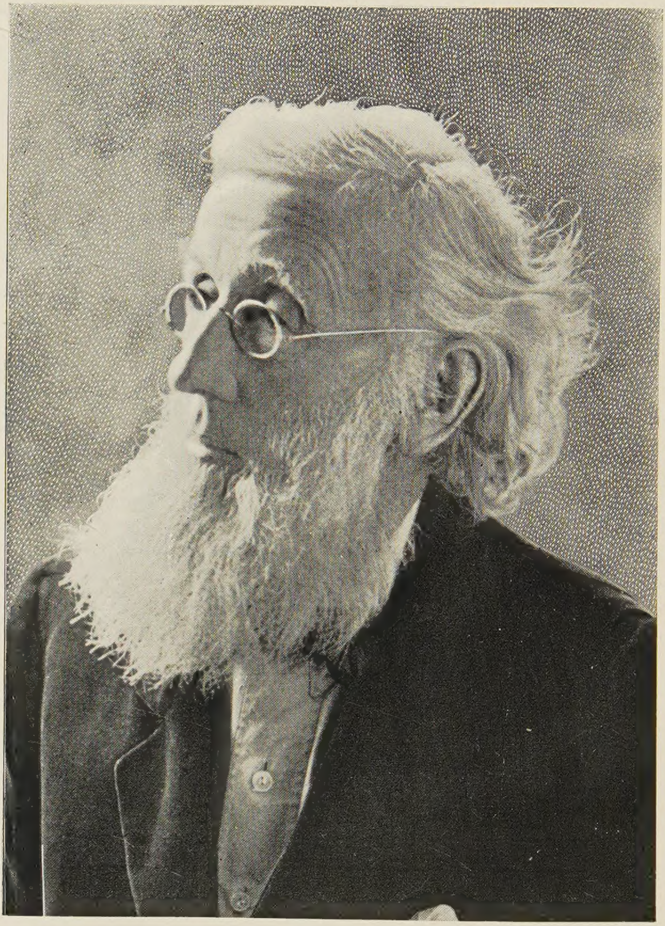

SIR NATHANIEL BARNABY, K. C. B.

19

NAVAL DEVELOPMENT

IN THE CENTURY

BY

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PREFACE.

The prime conception in a book on naval development has to depend, in an especial manner, upon the point of view of the writer. He might be a sailor. In that case it would be expected that the development of the aptitudes and characters of the seamen would be prominent. The difference between the able seaman of 1800 and the able seaman of 1900, and between the officers of the great navies of these two periods might be brought out so as to mark the advance in knowledge and, to some extent perhaps, in personal character in both officers and men. Or the book might have been entrusted to a marine engineer. He would find his craft suddenly brought on the scene at the beginning of the nineteenth century and growing so rapidly in importance that at its close he might regard himself as being able to build the ship, to drive her, and to command her in action with an enemy. Dependence upon the wind and upon sails for locomotion is so primitive a conception that he might be expected to speak of development only in terms of the power of steam machinery and of the results it has achieved and may yet achieve.

What has been done is to entrust it to a shipbuilder who has helped to build line-of-battle ships having no dependence upon steam, except in the galley coppers; and in later years other and far larger ships, dependent upon steam not only for their pro-

pulsion, but for fighting their guns, for making their signals, for working their boats, and for weighing their anchors. Whichever of these professions had been drawn upon one characteristic must have marked the successful historian. He would be proud of his connexion with such a service and he would confess that his delight in it had not been measured by the extent of his technical knowledge or by his own professional success, but by his sense of the infinite possibilities which lie open in it to clear-eyed strong-hearted human endeavour.

To know so much that he realizes his ignorance and insufficiency, this is the indispensable attainment in any one who as seaman, engineer, or shipbuilder seeks to record the results of the courage and patience and skill of those who have laboured in the development of traffic and of orderly government on the pathless seas.

London, 1902.

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NAVAL DEVELOPMENT OF THE CENTURY.

CHAPTER I.

THE ETHICS OF NAVAL DEVELOPMENT.

It may be as well to consider at the outset what may be called the Ethics of Naval Development.

A map of the world showing the approximate number of ships always on the ocean routes is an interesting study because it shows that certain roads are largely frequented; that the traffic on them steadily increases and that the tendency is to develop more and more the facilities for commerce at stations along such roads. Not less striking is the vast field of ocean over which there are not yet any lines of traffic or not enough ships upon the lines to attract attention. The road through the Bay of Biscay, up the Mediterranean and through the Suez Canal stands out in bold relief on account of the number of ships of regular lines always upon it. The Atlantic route from east to west comes next in bulk of traffic. One sees that some day a similar stream will cut across the great American isthmus and will make a south-western road connecting the British Channel and the English-speaking lands in the south seas rivalling the western road in its importance.

Southern America awaits development. We have

only to reflect upon its vast natural wealth and to note how feebly and ineffectually its few civilised inhabitants deal with it, in order to foresee great trade lines running between Europe and the magnificent South American rivers. The ships on these routes now are so few that they scarcely show on a trade route map.

Such a map, once prepared, grows in interest, and especially to those who feel they are responsible for protecting these roads and the great caravans upon them. One may see British officers poring over such a map and wondering how many ships England needs to protect this commerce.

Protect it against whom? And why should England regard herself as its protector?

The author is not one of those who regard war as contrary to the teachings of the Prince of Peace. Lasting good is only evolved in this world through strife and bloodshed. The song of the Angels was long ago mistranslated, for English-speaking people, out of the Latin, and we were made to believe that the promise was unconditional and was of the cessation of war and bloodshed. Latin and Greek alike made it clear that nothing of the kind was meant, and that peace has to go only with right doing and among the right doing. Righteousness must come before clean-hearted Peace, and the omission of this thought from the English authorised version of the Angels' Song has wrought lasting mischief. The mischief repeats itself year by year. Before the troubles in Armenia in the "Year of Shame," 1896, all matters connected with preparations for war were treated by superior people in England as being in the hands of unenlightened men. The maxim, that to secure peace nations should be prepared for war, was denounced as wicked.

Strangely enough these same people provoked by the Armenian Massacres condemned the inaction of the Lords of War in England. And in the contentions of public opinion to-day on South African troubles these same good Christian folk condemn the British government on the ground of lives lost, gold spent, and on the general poverty of the country which has been the field of the struggle. No Christian man should be content to argue on that ground. While injustice and unrighteousness exist in the world, the sword, the rifled breechloader and the torpedo boat become part of the world's evolutionary machinery, consecrated like any other part of it.

One cannot conceal from oneself that France is no more selfish, unjust and unrighteous in its national ideals than England is. Both countries have much to be ashamed of in the past and neither can trust the other to act always neighbourly. So with this mistrust on both sides of the channel the evolutionary machinery is daily perfected by the engineers and practised by the seamen in preparation for the day when France, in defence of her supposed rights, may make a raid into England or may seriously invade her or may at any rate wage war with her upon the seas. Then, says the naval officer, all these lines of commerce which move so peacefully across my trade route map will be dislocated, and all ships flying the English flag will be liable to confiscation or destruction.

France, at the head of civilisation, is the power whose war cruisers may come down as Red Indians used to do upon the mails crossing the American prairies. This British officer has personal friends among the French officers who would, as he foresees, carry out these raids upon commerce. The bitterness of feeling which marked the opening of the century

has wholly disappeared so far as naval men are concerned on both sides of the Channel and it could never be revived. Yet criminal folly on the part of the governments of these two countries may bring on a war. Nothing less than such folly could change the strong currents of commerce and social intercourse which day by day make for peace between Great Britain and France. In the *History of the Royal Navy* by Mr. Laird Clowes there is a very striking table of the losses of ships in war between 1803 and 1815. The loss of over eight hundred ships of war (in these two navies) must have provoked and sustained bitter feeling between the two combatants and their kindred and friends. No such prolonged strife would now be possible and no such long-drawn out agony. The table appears as an appendix to Vol. V of the history referred to. It is very striking as an illustration of the march of naval events in the early part of the nineteenth century.*

If the British naval officer, thus studying his trade route map, has France in his mind as the European Red Indian who is to interfere with trade why should Whitehall in the little island of the North Seas be the place above others where watch should be kept over the interests of the Poor Jack of the Seas?

This is so partly because of the large proportionate volume of British trade. But beyond this these roads which are threatened lie between British homesteads and the stoppage of communication between them cannot be endured by British folk.

In the event of war between England and another power the ships of neutrals would it is true carry

*With the consent of Messrs. Sampson, Low, Marston & Co. part of it has been given as an appendix to this book.

mails and passengers to British ports at home and in the colonies and possessions which were not blockaded. There would doubtless be, if the war were serious, a large transfer of flag. If it were not serious the government would probably undertake to guarantee against loss by hostile force, and so premiums of insurance would be kept at somewhere about the usual rates and transfer of flag might be avoided.

The international guarantee of immunity of neutral ships carrying enemy's goods against capture by a belligerent is not complete because the United States is not a party to the Declaration of Paris of 1856, but no powerful neutral is in the least likely to submit to confiscation of ships under its flag on the plea that they were carrying enemy's goods not contraband of war.

The United States stood out, and still stand out from this international understanding because the American government favoured a wider measure. They held that, the maritime Red Indians should have no right to interfere with peaceful traffic on the roads of the sea whatever the flag might be that carried the traffic even though it were that of a belligerent.

We are now approaching the Jubilee of the Declaration of Paris, and one may hope that before it is celebrated the view of the United States Government of 1854 to 1857 may prevail, and that private property at sea shall be declared sacred under any flag whether belligerent or neutral.

In England there is still a party that supports the issue of letters of marque to private vessels giving them authority to wage war against other private vessels under an enemy's flag. This party has lost influence since the British government signified its intention to incorporate the best of suitable private

vessels under its flag, at the outbreak of war. They would be armed, equipped and commanded as ships of war. But there is always a danger that in the heat of war a hard pressed belligerent may resort to privateering if he is free to do so.

To adopt a measure giving to the ordinary ship-owner the power to plunder trading ships because they happen to fly a foreign flag would be a return to barbarism. Perhaps the risk of this is not great. But there is a very serious aspect to the question. Place yourself by the side of the British officer of the Naval Intelligence Department as he cons over the ships on the routes which his thoughts patrol and measures the forces disposable to protect the routes.

He looks at the ships requiring to be protected, sailing ships and steam "tramps" by the thousand. How many ships will he want. He will tell you frankly that nothing will satisfy him. Every mean tramp flying the British flag is as the apple of his eye; it must be protected. He has long ago ceased to vex himself as to battleships and cruisers if they were only free to do their proper work, to protect the great centres of population and trade, but to what extent will they have to be diverted from this to protect these thousands of helpless ships on the trade routes?

So the British Navy Estimates grow year by year and the demand is that as the number and cost of the helpless traders increase, in the same proportion must money be invested in armour and guns to provide fast seagoing defenders for them.

There are only two conceivable ways in which this may be stopped. One is that the United States may so develop its merchant shipping as to become as interested as England is, and that she may put forward

once more her proposal, "The private property of the subjects or citizens of a belligerent on the high seas shall be exempted from seizure by public armed vessels of the other belligerent, except it be contraband."

If the United States and Great Britain agreed to this the concurrence of other powers is certain. Navy estimates in Great Britain, in France, in Germany, in Russia, in Italy, and in the United States would go once more into well defined channels and would no longer threaten to overrun the banks and overwhelm peaceful industries.

Failing this such governments as have a growing mercantile marine must take care that as it grows it shall develop warlike features within itself. It has full capacity for doing so. A ship, in no wise hampered in the performance of her profit-making duties, may possess, in rudiment, the qualities which will make her as formidable to ninety-nine of her trading companions as if she were a ship of war. The owners of such ships could be amply compensated for the necessary expense by a standing agreement to charter at agreed rates and for the payment of a retaining fee.

This system is in partial operation in England but it is opposed by naval officers, by the Navy League, and by other enthusiasts for a "Strong Navy" by which they mean such a fleet of regular ships of war as shall enable England to wage war with three European powers and secure at the same time all the weak vessels flying her flag all over the world against capture or destruction.

The statesmen who at the prospect of a war with Russia took up at home and abroad all such fast ships and equipped them at the stations where equipments had been stored in readiness for such an emergency

have never been forgiven by the Navy. They spent less than the cost of one British cruiser and this was held to be waste of money. If the ships so taken up had been bought by a vigilant enemy, as they might have been, it is impossible to measure the damage which such armed ships could have done on distant trade routes.

Such, as the author understands the question, are the moral principles underlying naval development. Warfare and strife are natural forces moulding the world and producing noble characters. We utter the prayer "Give peace in our time, O Lord;" but if the nation is at all in danger of Mammon-worship peace may be a curse rather than a blessing. The prayer for England, the one she most needs to offer, is "establish righteousness in our time, O Lord."

There are those who think that military and naval service is immoral. They do not go so far as Tolstoy and condemn the use of force as being immoral, but they affect the attitude of the Society of Friends and will not take part in the warlike training of the national forces.

One might point to the greatness of the lives of men whose occupation has been war; and still more to the lives of those who have taken up war as a duty in times of national danger. Or to speak more broadly take the classes of men of the same rank in society who have followed the pursuits of commerce and those of war and compare the characters formed. Compare a hundred British naval officers with a hundred stockbrokers or lawyers or company promoters, and does any one believe that the comparison as to strong, beautiful, moral character will be to the disadvantage of the sailors? The author, for his own part, would back the sailors against an equal number of clergymen for unselfish, manly living.

The fashion is to use the word unchristian instead of immoral and then to base the Christian ideal upon the Ethics of the Sermon on the Mount which clearly will only allow the return of good for evil and condemns the force and reprisals of war.

Pictures are drawn by such men of the Prince of Peace appearing in a vision to the dying sailor or soldier condemning him as he lies helpless and in agony because he is found on a field of battle with dead foes around him.

There is a Christianity which evolves an unselfish God-fearing life on shipboard and in the din and smoke of battle, and it is a nobler thing than the Christianity which seeks to make the best of both worlds and takes part in no battles save those of personal self-interest.

Ruskin says in his *Crown of Wild Olive:* "I found that all great nations learned their truth of word, and strength of thought, in war; that they were nourished in war, and wasted by peace; taught by war, and deceived by peace; trained by war, and betrayed by peace;—in a word, that they were born in war, and expired in peace.

"The habit of living light-hearted, in daily presence of death, always has had, and must have, a tendency both to the making and testing of honest men.

"War in which the natural instincts of self-defence are sanctified by the nobleness of the institutions, and purity of the households, which they are appointed to defend: to such war as this all men are born; in such war as this any man may happily die; and forth from such war as this have arisen, throughout the extent of past ages, all the highest sanctities and virtues of humanity."

Three prominent features of war in its modern

forms have marked themselves on the past century. War has made its weapons as destructive and as appalling as was possible: "It has sought to render itself as little onerous as possible to the powers that remain at peace: it has sought to restrict its operations to the regularly organized forces of the country."

In the chapters on Armed Ships, on Guns, and on Rams and Torpedoes the course of development of the weapons will be seen. In the chapter on private ships in their relations to belligerents, the progress of the forces tending to restrict the area of warlike operations and to avoid causes of offence to peaceable neighbours will be set forth. It is very gratifying to an Englishman to be able to say that when the existence of these limiting forces was first publicly recognized it was in words from the throne of England. The words above quoted are from the Royal Proclamation of March 28, 1854, concerning the conduct of the impending war with Russia. It was a proclamation becoming a great Queen; a Queen worthy of a people who love peace but are not afraid of war.

It is pleasant to remember also that the French and the British governments were in full agreement in the course then taken.

CHAPTER II.

SLOWNESS OF DEVELOPMENT UP TO THE END OF THE EIGHTEENTH CENTURY.

One of the most striking things in connection with the progress of the navy is that for a great part of the nineteenth century there was but little movement in the direction of change in the kind of ships in use in peace and in war. That we shall see as we look closely into the nature of the development during the century which has to be recorded. It may be well to note how this conservative temper has marked naval matters for ages. There is but little trace of it in naval affairs to-day and it is this change which is so remarkable. It is just forty years ago that the author in considering mechanical invention in its relation to the improvement of naval architecture called the attention of the Institute of Naval Architects to this sluggishness of movement in naval matters and sought to bring out such marks of progress as there were by taking steps of a century in length backwards during the preceding six hundred years.*

NAVAL DEVELOPMENT IN 1260.

In the year 1260, vessels of all sizes were constructed, and to a certain extent equipped, with a view to warlike operations. This state of things existed for many years afterwards, so that if we can dis-

*Vide Transactions 1860.

cover the principal features of the ships used in the various sea-fights of these periods, we shall possess those of the English marine in general.

The most formidable vessels used in the reign of Henry III., who occupied the throne from 1216 to 1272, were the royal galleys. They appear to have had but one, or at most two tiers of oars, with platforms on each side of the vessel over the heads of the rowers. On these platforms were stationed the soldiers, clad in mail, and armed with swords and lances. On the bulwarks in front of them were ranged their shields, made of polished steel. These galleys had but one mast, which was frequently painted with a bright colour or gilded. From the mast, from the extremities of the yard, and from every other available place, gaudy pennons and banners floated on the wind. The sail was made of cotton, painted or embroidered with the arms of the king or some other eminent person. It would appear from the length of the yard in some of these vessels that the sails were frequently triangular or lateen. At the summit of the mast was a kind of circular box, capable of containing several men. These "tops" in the larger sort of vessel would hold six men. Their duty was to haul up large stones, bricks, and bars of iron from below, and to throw them upon the decks and into the holds of the opposing vessels; and so slightly built were these vessels, that the missiles thus thrown into their holds frequently penetrated their bottoms. They had no means of pumping out the water which entered the vessel through the holes made in this way; and it was no uncommon thing to see half the knights baling out the water, while the others were engaged in a hand-to-hand conflict with the enemy, to whose vessel they had firmly secured themselves by grappling-irons.

At each extremity of the vessel there was a raised platform called a castle, from which, as well as from the decks, large square-headed arrows, winged with feathers or with brass, were thrown by the archers, either by hand or by a machine called a springald. Those also who were fortunate enough to secure the weather-gage frequently threw unslaked lime into the eyes of their opponents. But they possessed a more terrible means of destruction than any of these in the celebrated Greek fire, which appears to have been used up to the time of the introduction of ordnance, more than a century later. Each galley had, besides, an iron beam called a spur, projecting from the prow, with which it pierced the sides of its adversaries. We are informed on good authority that Richard Coeur-de-Lion while on his way to Palestine, fell in with a very large Turkish vessel filled with soldiers. He attacked her with his galleys, but her sides were so high that his soldiers could not reach her decks with their lances, while they suffered severely from the arrows and other missiles thrown down upon them. Richard then ordered his galleys to recede, to form a line, and then to advance at full speed and strike her with their iron spurs. This being done, her sides were stove in many places, and she speedily sank.

The sailing-vessels known as "great ships," and which were used in conjunction with galleys for war purposes, appear to have been of four or five hundred tons burthen, according to our present builders' measurement. They were probably eighty or ninety feet long, and from thirty to thirty-five feet broad.

NAVAL DEVELOPMENT IN 1360.

At this period Edward III., the conqueror of Cressy, was king of England, and had recently won

for himself the title of "King of the Sea" by his distinguished conduct in the great naval fight of "Espagnols-sur-Mer." In this engagement, the largest vessels, called "cogs," had from 150 to 300 men each, including sailors, archers, and men in armour. The mailed soldiers were ranged round the sides of the ships, having a breastwork in front of them glittering with shields, and apparently about five feet high. The castles at the extremities of the vessels, which were filled with archers, were so fragile, that by the shock of a collision with another vessel they were sometimes carried quite away, and their occupants thrown into the sea. Many of the vessels were furnished with a rudder on each quarter, or with a single one hung to the stern-post. Previously to this period the usual mode of steering had been by oars.

It was during the reign of Edward III. that guns were first used on the sea; and it seems to have been in the same reign and at the same period that the last row-galleys were constructed in England. We hear, however, at a later period, of vessels of a different construction, called "galleons," which could be propelled by oars worked between the guns. Such vessels appear to have been used chiefly by the Spaniards, who still possessed some in the time of Elizabeth. Other nations appear also to have continued to use the common galley, with guns mounted at the extremities. As late as 1405, the English government applied to the King of Portugal for the use of his galleys in the war with France.

NAVAL DEVELOPMENT IN 1460.

At this time guns of iron, brass, and copper, throwing stones and lead shot, had come into general use,

and the sailing-vessels called "cogs" and "caracks" held the foremost place in the navy. A vessel of this kind, building for King Henry V. at Bayonne in 1419, was 112 feet long on the keel, and 46 feet broad. The elevated and partially detached castles of preceding periods appear to have been suppressed, or rather incorporated with the rest of the vessel, by carrying up the planking and berthing. About this time, also, cabins were introduced for ordinary purposes, including a buttery, pantry, spicery, ewery, and chandlery. The central portions of the holds of these ships were occupied by the galley and cooking-apparatus, so that all the stowage was at the extremities. The amount of stowage was so small that every ship fully manned had a tender or "victualler" to accompany her. Pumps of some kind were in use; and we observe that tow immersed in tallow was employed for caulking the seams of the bottom below water.

NAVAL DEVELOPMENT IN 1560.

During the preceding century, by the introduction of a very simple improvement, suggested, it is said, by Descharges, a ship-builder of Brest, a remarkable change was effected in ships-of-war. This improvement was the formation of port-holes, so that ships could have more than one tier of guns. The dimensions of ships seem to have been rather diminished than increased since the early part of the preceding century, as Sir Walter Raleigh considered the best dimensions of a great ship to be 100 feet in length (i. e. of keel), and 35 feet in breadth. This proportionate decrease in breadth without doubt greatly improved the appearance and the qualities of the ships. There seems, however, to have been some

naval architect in Scotland who was greatly in advance of his age, as we hear of the "Great Michael," built there in the early part of the sixteenth century, which was 240 feet long, and 56 feet broad, and had sides 10 feet thick. She was lost soon afterwards in the Channel; and probably her unhappy end was taken as a warning by the prudent men of that day.

In 1515 the "Henri Grace de Dieu" was built. This was a four-masted ship, mounting in all 122 guns, although she was probably not more than 100 feet long on the keel. She had 30 guns on each of the two principal decks, and three tiers of guns above these at the head and stern; so that the extremities of the ship must have been 30 or 40 feet higher than the midship part. Guns from each of these upper tiers commanded the spar-deck. It appears from the drawings of the ship, that the forecastle, like that of a much earlier period, was broader than the top side of the ship, and projected considerably beyond it. Each mast had two round tops and three yards. Although this increase in the number of yards was a great improvement, the ship must have been still unable to sail near the wind, as the distance between the masts was very limited, and with the exception of the two lateen sails on the after masts, they do not appear to have used fore-and-aft sails. They had found that the ships had a great tendency to "hog," or to sink at the extremities; and to remedy this defect they altered their arrangements in the hold, stowing in the middle of the ship, rather than at the extremities, and removing their cooking-apparatus from the hold to the deck above. They had just learned to use long mooring-cables for easing the strain upon the anchors, and had applied capstans for raising the anchors. Wood-sheathing had been introduced to prevent the oakum

from washing out of the seams, and to obstruct the entrance of the worm. Chain-pumps were also coming into use.

After the accident to the "Mary Rose," occasioned by the lowness of her ports, and by the fact of the guns being unbreeched, as was the custom, they raised both the gun-decks, or overloops, as Sir W. Raleigh calls them, and fitted breechings to the guns.

NAVAL DEVELOPMENT IN 1660.

During this century, also, a further advance had been made in the art of shipbuilding. This was chiefly due to the labours of Mr. Phineas Pett of Cambridge University. He appears to have been one of the founders of the Shipwrights' Company which was established in 1606, and became of great consequence. For a considerable period, all the designs of ships for the Royal Navy were submitted to them for approval. Mr. Pett built at Woolwich, in 1637, the first English three-decked ship-of-war, the "Royal Sovereign," or the "Sovereign of the Seas," as she is sometimes called. She was afterwards cut down to a two-decked ship. We see in her a great increase in dimensions over the vessels of the preceding century. Her dimensions were—

		Feet.
Length on the gun-deck		173
Breadth extreme		50
Depth in hold		20
Burthen in tons	1,861	

She seems to have carried nearly 150 guns.

If we compare this ship with some of the two-decked line-of-battle ships existing quite recently in the Royal Navy, we shall see but little difference in dimensions. Take, for example, the "Hogue;" her dimensions were—

	Feet.	Inches.
Length on the gun-deck	184	0
Breadth extreme	48	4
Depth in hold	21	0
Burthen in tons. 1,861		

There is also a remarkable similarity in the form of bottom of the "Royal Sovereign" and of ships like the "Hogue" built at the close of the eighteenth century; but in height out of water there is a wide difference. The stern of the "Royal Sovereign" could not have been less than 50 feet out of water, while that of the "Hogue" was only 23 feet. The excessive height made the ships of this period so crank, that many of them had to be girdled with thick plank before they could be trusted at sea.

The most remarkable improvements visible at this period were in the practical construction of ships. We find here for the first time the mode of framing the stern by transoms, which existed nearly up to our own time. The entire mode of framing ships was evidently much more substantial, and they, provided that the timber were well-seasoned, became more durable. This ship of Pett's, for example, built with the famous ship money, went through all the wars of the Commonwealth, and was finally destroyed by fire at Chatham, while she was undergoing repair, and after she had seen sixty years' service. We may obtain a

very good idea of the substantial character of their construction from a record still in existence, which shows that the weights of the hulls were very nearly equal to half the load-displacement, a proportion which holds up to our own time. This record points to another important step which had just been taken, in the discovery made by Mr. Deane, afterwards Sir Anthony Deane, of the mode of measuring the solid contents of the immersed portion of a ship's hull, by which means naval architects became able for the first time to predict the depth to which the ship would sink, both when light and when laden.

NAVAL DEVELOPMENT IN 1760.

At this period the dimensions of a 90-gun ship were—

	Feet.
Length on the gun-deck	176
Breadth extreme	49
Depth in hold	21
Burthen in tons 1,827	

Those of a 44-gun frigate were—

	Feet.	Inches.
Length on the gun-deck	127	0
Breadth extreme	36	3
Burthen in tons 725		

Duhamel recommended, with regard to these

frigates, that those which were intended to be very fast should have their length increased to four times their breadth.

About this time great attention was paid to the means of preserving ships from decay. Cross-chocks were introduced at the heels of the first futtocks, and limber courses were formed by the side of the keelson, with limber boards fitted over them. The mode which had hitherto been in use for bending planks, by charring them on one side and wetting them on the other, was superseded by the process of kilning. Ships were also ordered to stand to season for a considerable period after they were in frame. But the large masses of timber in the vertical riders and hanging and lodging knees, if not properly seasoned, the absence of fillings, and the use of great quantities of shingle ballast to give stability to the ships, all tended to promote decay. Some of the ships of this period were sheathed with lead fastened with copper nails, and others had wood sheathing, which was either filled with large-headed iron nails, or graved with a mixture of pitch, tar, and brimstone.

NAVAL DEVELOPMENT IN 1810.

And now we come to 1810; a period at which the English Royal Navy was numerically stronger than at any other time before or since. It comprised 248 ships-of-the-line, exclusive of those on harbour service, and 290 frigates. There were in all 1,239 ships. In 1810 the "Caledonia," a first-rate of 120 guns, afterwards the "Dreadnought," Hospital-ship at Greenwich, had just been launched. She was then the largest ship in England. Her dimensions were—

		Feet	Inches.
Length on the gun-deck		205	0
Breadth extreme		53	8
Burthen in tons	2,616		

It is surprising to observe how little difference there was between the vessels of this period and those of nearly 200 years previously. Almost the only things of note were the reduction in height above water, forward and aft, and a slight increase in dimensions. The proportion between length and breadth had undergone but little change; in the "Royal Sovereign" it was 3.46 to 1, and in the "Caledonia," 3.82 to 1. There was in the ships of these two periods almost the some arrangement of decks and ports; the same thin boarding in front of the forecastle; the same mode of framing the stern; the same disposition of the outside planking in lines crossing the sheer of the ports; nearly the same rig; the same external rudder-head, with a hole in the stern to admit the tiller; and probably the same mode of framing the hull. For the ships of 1810 had no diagonal framing of wood or iron, but the old massive vertical riders; no shelf or waterway to connect the beams with the side; no fillings above the floor-head; and no dowells in the frames. Ships were still moored by hempen cables, and still carried immense stores of water in wooden casks.

Up to this period there had been during the 550 years through which we have passed a gradual progress, which had consisted mainly of approximation to the forms and arrangements of Italian, Portuguese, Spanish, and French ships, all of which had been in their turn superior to English ships. The same

sluggishness which had prevailed for centuries prior to the invention of gunpowder seemed to be again settling on the navy, until the advent of steam made it start into new life. The great improvements in practical construction introduced by Sir Robert Seppings just after 1810, while they are an exception to this position, serve to illustrate it. The weakness in the framing of the old sterns and their defencelessness had been the subject of complaint for many years; yet they were left to be patched up by plasters of wood or iron when they seemed disposed to drop off; and to be blown out by impatient captains who wished to get a gun to bear upon an enemy who was raking him with impunity.

There is a report of an action fought between the "Blanche" and "La Pique" frigates in 1794. The writer of the report says: "In the action, the Blanche's mizen-mast and shortly after her main-mast were shot away. Just before this happened, we had, with the intention of boarding, put our helm a-starboard, and run across the stem of "La Pique," her bowsprit coming over our quarter-deck. To secure her in this situation, Captain Faulkner and myself made every rope we could get hold of fast round our capstan; and the end of the hawser being handed up, we effectually secured her by passing it also round her bowsprit. The "Blanche's" main- and mizen-masts being shot away, and the head sails filling, she payed off before the wind, thus bringing "La Pique" astern towing by the bowsprit. We were immediately much annoyed from her quarterdeck guns, well served and pointed forwards, without our being able to return a gun, having no stern-ports on the main-deck. We had no alternative left but to blow out the stern-frame. All the firemen, with their buckets, were

assembled in the cabin, and both the after-guns pointed against the stern-frame. This made a clear breach on both sides, and the fire was immediately extinguished. We now raked her with great effect, clearing her decks fore and aft, and they soon called out that they had surrendered."

The great weakness of the upper part of the bow was also known, and line-of-battle ships which had been cut down to frigates gave examples of an improved form, yet nothing was done towards introducing it. Duhamel, in his *Architecture Navale* of a hundred and forty years ago, mentions a proposal to cross the ceilings of ships by oblique iron riders; and a ship built in France in 1780 had diagonal riders in the hold over the ceiling. It had been proposed, in 1763, to fill in the spaces between the timbers from the waterline downwards, and to caulk the fillings inside and outside, for the purpose of adding security to the ship and excluding impure air. And Mr. Fincham says that both shelf-pieces and thick waterways had been in use in French and other foreign vessels before Sir Robert Seppings proposed the application of them to English ships. Thus, while the paper read by Sir R. Seppings before the Royal Society in 1814 appears, at first sight, to have been highly novel and speculative, and the subsequent introduction of its recommendations into the navy an exception to the ordinary cautious rule, neither is really the fact.

It is curious to observe, moreover, what a limited influence the experience and intelligence of private ship-builders appear to have had during this long period. However slow the progress of the government builders, private ship-builders were content to follow in their wake. The first letters-patent granted for improvements relating to ships bear the date,

January 17, 1618. I have gone through all the patents relating to ships granted between this period and 1810, and I can find no improvement worth recording except in the manufacture of sheathing and the construction of pumps. Indeed, between the years of 1618 and 1800 more than one-third of the patents claim improvements in ships' pumps.

CHAPTER III.

THE SAILOR AND HIS HOME FROM A BRITISH POINT OF VIEW.

The seaman has been a distinct type for generations, and we are proud of the hardy, careless, active man, familiar with all the perils of the stormy seas. The ship in which he serves is a mere instrument, not easily made interesting. Ruskin has appealed to our pathetic sense in favour of the line-of-battle ship with its ribs and sides of strenuous oak, which will writhe and bend and splinter under attack before it will submit. But the treacherous iron or steel, which looks so strong and submits to perforation so easily, has no such pathetic claims.

Yet the ship whether of steel or wood, is an important factor in the making of the seaman's character. The man who has spent his life in a ship propelled by sails will have aptitudes and abilities which cannot be acquired in a steamer. Large numbers of seafaring men are employed who are not seamen at all. The ship-builder and the engineer may, in the course of time, make life on shipboard so much a matter of routine and mechanism that we shall find only seafarers where we have looked for seamen.

When steam-ships were first introduced the number of persons employed, in proportion to tonnage, was much greater in the steamer than in the sailing-ship. But that is no longer so. Sailing-ships and steam-

ships of the same size have now, practically, the same number of persons in the crew. Those connected with machinery of different kinds have displaced seamen.

The conditions of his home and of his service in it have been modifying the character of the British seaman until the officers of the Royal Navy regard the Naval Reserve man, serving in ships where seamanlike training exists in perfection, as a useless person. One says they "do not want him"; another says that "he cannot shoot, and he does not know what to do."

This decline in the character of the British seaman has been brought about partly by the suppression of sails, but partly also by the complete suppression of the ships of the Mercantile Marine until quite recently, as an element in the national defence. This policy of suppression is modern, and falls within the last fifty years. For some years prior to 1853 it was the practice to insert in all postal contracts clauses providing that the ship should be able to carry guns of the largest calibre then in use, and should be thoroughly seaworthy in all respects. This brought all mail steamers under Admiralty supervision. In 1852 a committee on the subject reported that the vessels of the Mail Packet Service would not make efficient substitutes for regular men-of-war, but that they might be fitted as armed packets or as armed troop-ships. In a second report the committee excluded iron vessels from those which might be considered available for war purposes, but did not give any reasons for this most fateful decision.

A Treasury Committee was appointed in 1853 to consider the question of the cost of the Mail Packet Service, and it recommended that future Mail con-

tracts should be wholly free from armament clauses. How different and how much more satisfactory the story of shipbuilding might have been had the Postal Service been kept in touch with the Royal Navy.

Another ground of complaint made by those who think the character of the sailor is rapidly falling is that there is a large foreign element in the British Mercantile Marine. It is noted that in 1891 forty-seven per cent. of the able seamen in British Ships were non-British.

In 1898 the President of the Board of Trade said the decline of British sailors in the Mercantile Marine has been a matter of considerable anxiety to all those who have the interest of the country at heart and many suggestions have from time to time been made with a view of endeavouring by some means or other to check that decline. In the year 1891 there were 41,590 British sailors on board British ships and in 1896 the number had decreased to 35,020 showing a falling off of 6,570.

In 1891 there were 13,432 foreigners on board British ships and in 1896 the number had increased to 14,469. He did not dispute that a great many of these foreigners made good seamen, but the country would prefer that its ships were manned by British sailors. "If at the present moment the Naval Reserve were called out it would leave our Mercantile Marine almost entirely in the hands of foreign sailors."*

Concerning these foreign sailors a recent writer on the British Merchant Service (Mr. R. I. Cornewall-Jones) says: "There are many reasons that conduce to this gradual decline in the numbers of British merchant-seamen and unquestionably one is the

*See appendix I.

steadily falling rate of wages. The pay of an A. B. on board ships out of the port of London is now exceedingly low, £2.15.0 a month being about what Jack gets at the present time. This to a great extent is the result of foreign competition. Low as the present rate of pay is on board British ships it is higher than the foreign sailor can get on board ships of his own country, and so he comes to us; and besides that, most British ships are better victualled than foreign ships, so that the foreign sailor gets a double advantage, from his point of view by shipping on board British vessels,—he gets better wages than he could get on board his own ships and he is better fed into the bargain.

"There is one reason, however, that weighs considerably with skippers and mates in favor of employing 'Dutchmen' in the place of Englishmen, and it is a reason that British sailors would do well to bear in mind; and that is that without any doubt the foreign sailor does not get drunk to anything like the same extent that the British sailor does."

The outcry against foreign sailors is got up a good deal in ignorance of facts. A writer in the *Times*, September 21, 1898, says that "by the 13 George II., c. 3, foreigners not exceeding three-fourths of the crew were permitted in British vessels, and in two years to be naturalised." In 1770 by the 11 George III., c. 3, merchant ships were allowed to have three-fourths of their crews foreigners till February 1, 1772. Acts permitting the same proportion of foreign seamen and extending the time were passed in 1776, 1778, 1779, 1780, 1781 and 1782. A similar act was passed in 1792. It was in contemplation to reduce the foreign proportion, after the war, to one-fourth. In 1794 it was enacted (34 George III., c. 68), "for the encouragement of British seamen," that

after the expiration of six months from the conclusion of the war vessels in the foreign, as distinguished from the coasting, trade were to have their commanders and three-fourths of their crews British subjects. From the wording of the act it seems to have been taken for granted that the proportion of three-fourths *bona fide* British-born seamen was not likely to be generally exceeded. It will have been observed that in all the legislation mentioned, from the time of George II. downwards, 'it was assumed as a matter of course that there were foreign seamen on board our merchant vessels. The United States citizens in the British Navy, about whom there was so much discussion on the eve of the War of 1812, came principally from our own merchant service and not direct from America. It is remarkable that, until a recent date, the presence of foreigners in British vessels, even in time of peace, was not loudly or generally complained of. Mr. W. S. Lindsay, writing in 1876, stated that the throwing open the coasting trade in 1885 had 'neither increased on the average the number of foreigners we had hitherto been allowed to employ in our ships, nor deteriorated the number and quality of British seamen.' "

But besides this we have to note that the ships to be manned are British only in name. By a simple announcement at the Custom House the ownership may be transferred to foreign capitalists and the ships and crews would work under another flag.

The anxiety of the President of the Board of Trade is hardly intelligible in the face of these facts.

The proper way to look at the matter seems to be this. Maintain carefully the superior character of the British ships so that men of good character of all nationalities may find in them a clean and wholesome life. The language difficulty will always raise a bar-

rier against men of another speech, so that English-speaking folk and Scandinavians who have some aptitudes for the tongue must make up the bulk of the crews. The time is coming, so the author thinks, when no British seaman will incur penalty should he enter under the United States flag in a time of war between the United States and some other power, England being neutral; and when the United States government may take the same course towards her citizens serving in British ships. The thing to be striven for by English-speaking folk, in the interest of all men, is that commerce on the seas shall not be vexed and injured by ships of war but shall be protected by a Peace of the Seas guaranteed by Great Britain and the United States.

In an article contributed by the author to the Engineering Magazine (Montreal, 366 St. James St.)* he said speaking of the identity of the ideals of the British and the American people: "When the ideals of two parties are seen to be alike, and the opportunity for noble work in common is realised, another stage is entered on; the lover brings gifts. In this case neither party has any gift to offer of which the other stands in need. The gifts can be only expressions of good will and confidence.

"There is, first, the gift of jcint nationalisation for the seamen, so that every enrolled seaman may, for the time being, claim the nationality of the flag under which he may be serving, whether it be the British Ensign or the Stars and Stripes.

"According to the British foreign enlistment act of 1870, America is a foreign State; the act reads as follows:

'If any person, without the license of Her Majesty,

* October, 1898.

being a British subject, within or without Her Majesty's dominions, accepts, or agrees to accept, any commission or engagement in the military or naval service of any foreign state at war with any foreign state at peace with Her Majesty, and in this act referred to as a friendly State; or whether a British subject or not within Her Majesty's dominions, induces any other person to accept, or agree to accept, any commission or engagement in the military or naval service of any such foreign state as aforesaid, he shall be guilty of an offence against this act, and shall be punishable by fine and imprisonment, or either of such punishments, at the discretion of the court before which the offender is convicted.

'If any person, without the license of Her Majesty, being a British subject quits, or goes on board any ship with a view of quitting Her Majesty's dominions, with intent to accept any commission or engagement in the military or naval service of any foreign state at war with a friendly state, or, whether a British subject or not, within Her Majesty's dominions, induces any other person to quit, or to go on board any ship with a view of quitting Her Majesty's dominions with the like intent, he shall be guilty of an offence against this act, and shall be punishable by fine and imprisonment, or either of such punishments, at the discretion of the court before which the offender is convicted. If any person induces any other person to quit Her Majesty's dominions, or to embark on any ship within Her Majesty's dominions, under a misrepresentation or false representation of the service in which such person is to be engaged, with the intent, or in order that such person may accept, or agree to accept, any commission or engagement in the military or naval service of any foreign state at war with a friendly

state, he shall be guilty of an offence against this act, and shall be punishable by fine and imprisonment, or either of such punishments, at the discretion of the court before which the offender is convicted.'

"The gift offered to the United States should be the right to claim every British seaman or officer under her flag as an American citizen, made so by the flag during his period of service. Next she should be invited to make an exchange of gifts. Citizens of the United States serving under the British flag should also be held to have changed their nationality during such period of service. Acts which would be treasonable if committed by British seamen under the British flag should be regarded as equally treasonable when committed by an American under that flag. The same rule should apply to Britishers serving under the Stars and Stripes. The time would come when honours from the crown would be won by American citizens serving under the British ensign. However high those honours might be, it is to be hoped they would be offered gladly and worn with pride. America should be invited also to join Great Britain in establishing, on the coasts, state elementary nautical free schools for giving two years' training at the public expense to lads living in the neighbourhood of the schools and desiring such training, the lads to be perfectly free, during their training or after its completion, to engage in ships of any nationality, or otherwise to dispose of themselves. Their speech would naturally favour their entering under the American flag or the British flag, if they decided to follow the sea. If we thus gave each other our sons, we should, as Mr. Gladstone said, corroborate the bonds which unite us."

The severance of the Postal Service from its posi-

tion as auxiliary to the Royal Navy has affected the ships as well as the men. The comparative weakness of the modern iron or steel ship, against blows under water, is obvious, yet self interest on the part of the owners and insurers has been allowed to be the sole measure of the amount of provision that should be made in their ships to remedy this weakness.

Consider what this weakness is. It often happens that an iron or steel ship is sunk when only a comparatively small hole is made in a single compartment. The badly arranged bulkheads do not even delay the sinking. The water spreads itself differently owing to the presence of the bulkheads, but that is all. Instead of levelling itself from end to end throughout the ship, and gradually rising all fore and aft, the water first fills one compartment, then finding the top of the partition separating it from the adjacent compartment has been brought below the level of the outside water, it proceeds to fill that compartment, and so on.

In the year 1866 the question of division into compartments was fully debated by an influential committee of naval architects, shipbuilders, ship owners, Lloyds' surveyors, and sailors. That committee was the Council of the Institution of Naval Architects.

That Council decided that no iron passenger-ship is well constructed unless her compartments be so proportioned that she would float safely were *any one* of them to fill with water, or be placed in free communication with the sea.

They recommend that all iron ships should be so divided that not only the one largest compartment, but *any two adjacent* compartments might be given up to the sea without sinking the ship.

It might be supposed that such a decision, brought

as it was under the notice of the Board of Trade by the Council of the Institution, would have been followed by some instructions to the surveyors. But no such course was taken, and in 1876, ten years after the publication of the views of the Council of the Institution of Naval Architects, only two or three owners of steamships made it a rule to build their ships on these principles.

In the years 1881-1883 there was lost, from various causes, within twenty-one months, one hundred and twenty British iron steamships. Every one of these was in the condition that they had some one single compartment, at least, the filling of which would have caused the ship to founder.

In 1889, there was added to the British register about 1,000,000 tons (gross) of steamships. Of these, not one-third could lay claim to have been built with any intentional and satisfactory regard to safety by means of watertight bulkheads.

Fifteen years after the date of the promulgation of the views of the Institution of Naval Architects, the following ships, mostly passenger ships, which did not comply with the minimum condition as to reasonable security were in active service at sea.

The ships are grouped according to size, and the portion of each ship is named which would if damaged below water cause her to sink.

GROSS REGISTER TONNAGE OVER 4,000 TONS.

Ships.	*Compartments.*
No. 1.	Main hold.
" 2.	Every part through 360 feet.
" 3.	Every part abaft collision bulkhead.
" 4.	Every part abaft collision bulkhead.
" 5.	Main or after holds.

Ships.		*Compartments.*
No.	6.	Every part through 330 feet.
"	7.	Every part abaft collision bulkhead.
"	8.	Every part abaft collision bulkhead.
"	9.	Machinery space, or after hold.

GROSS TONNAGE 4,000 TONS TO 3,000 TONS.

Ships.		*Compartments.*
No.	1.	Every part abaft collision bulkhead.
"	2.	After hold.
"	3.	Every part through 350 feet.
"	4.	Main or after holds.
"	5.	Fore main or after holds.
"	6.	Fore main or after holds.
"	7.	Every part through 390 feet.
"	8.	Every part abaft collision bulkhead.
"	9.	Every part abaft collision bulkhead, except machinery space.
"	10.	Every part abaft collision bulkhead.
"	11.	Every part abaft collision bulkhead, except machinery space.
"	12.	Every part abaft collision bulkhead, except machinery space.
"	13.	Every part abaft collision bulkhead.
"	14.	Every part abaft collision bulkhead.
"	15.	Every part outside machinery space.
"	16.	Every part abaft collision bulkhead.
"	17.	Every part abaft collision bulkhead.
"	18.	Every part abaft collision bulkhead.
"	19.	Every part abaft collision bulkhead.
"	20.	Every part abaft collision bulkhead.
"	21.	Every part abaft collision bulkhead.
"	22.	After hold.
"	23.	Every part through 310 feet.
"	24.	After hold.
"	25.	Every part abaft collision bulkhead.
"	26.	Every part abaft collision bulkhead.
"	27.	After hold.
"	28.	After hold.
"	29.	Every part abaft collision bulkhead.
"	30.	Every part abaft collision bulkhead.
"	31.	Fore or after holds.
"	32.	Machinery space, or after hold.
"	33.	Every part abaft collision bulkhead.

GROSS TONNAGE 3,000 TONS TO 2,000 TONS.

Ships.	*Compartments.*
Nos. 1 to 54.	Every part abaft the collision bulkhead.
No. 55.	Fore or after holds.
" 56.	Main hold.
" 57.	Every part abaft machinery space, or 80 feet before it.
" 58.	Every part outside machinery space.
" 59.	Every part through length of 260 feet.
" 60.	Every part through length of 250 feet.
" 61.	After hold.
" 62.	Every part outside machinery space.
" 63.	Machinery space or after hold.
" 64.	Main or after holds.
" 65.	Every part outside machinery space.
" 66.	Every part for length of 230 feet.
" 67.	Every part for length of 260 feet.
" 68.	After hold.
" 69.	After hold.
" 70.	Every part outside machinery space.
" 70.	Fore and after holds.
" 72.	Every part outside machinery space.
" 73.	Every part outside machinery space.
" 74.	After hold.
" 75.	After hold.
" 76.	Every part outside machinery.
" 77.	After hold.
" 78.	Main or after hold.
" 79.	Machinery space or after hold.
" 80.	Every part for 320 feet.
" 81.	Every part abaft machinery space, and 80 feet before it.
" 82.	Every part outside machinery space.
" 83.	Machinery space or after hold.
" 84.	After hold.
" 85.	Every part outside machinery space.
" 86.	Main or after hold.
" 87.	After hold.
" 88.	Every part for 280 feet.
" 89.	Every part for 240 feet.
" 90.	Every part for 330 feet.
" 91.	Every part for 260 feet.
" 92.	Machinery space or after hold.
" 93.	Machinery space or after hold.
" 94.	Fore, main, or after holds.
" 95.	Machinery space or after holds.
" 96.	Every part fcr 270 feet.

GROSS TONNAGE 2,000 TONS TO 1,000 TONS.

Of these 58 would have sunk if damaged under water anywhere abaft the collision bulkhead, and the remainder of the ships, of this size, in one or other of the various ways described for the larger ships.

Those under 1,000 tons were defective in the same ways, and need not be given in detail.

The bulk of the well-divided steamers now existing come under the rules of Lloyd's Register Committee of 1882, when it was happily decided that steam-vessels 280 feet long and above, proposing to pass their survey, must have a certain number of efficient bulkheads, efficient; i. e., in the sense we are considering, increasing this number as the ships increase in length. Seeing that this Register is a voluntary association with no statutory powers, it has probably done as much as it could in the right direction.

Its influence for good has been so considerable that it would be impossible now to prepare a list of the more distinguished existing steamships presenting such unsatisfactory features as the liners and other well-known ships did before 1882. Immediately before that date iron and steel sailing-ships were, with rare exceptions, without compartments. They had only a collision bulkhead. It must not be understood that matters with them have much improved. It is in the larger steamships that the action of Lloyd's surveyors has been so influential as to make it impossible for any one in the future to make such a list of large and important badly divided ships as has been given above.

The Institution of Naval Architects has done much continuously to bring facts and principles into prominence. As to insurers or underwriters they have never

been known to move a finger to improve shipping, except indirectly through the Registers. The only hope of improvement lies with owners themselves, not with the builders; and with Lloyd's Surveyors.

To these must now be added the various Navy Departments who engage merchant-ships for war service. Such ships are carefully bulkheaded, and the influence of good building in them will affect all other shipping by the mere force of good example.

It is impossible to avoid the reflection that if there was and is this carelessness and recklessness as to the security of the ships, not much forethought would be expended on the appointments of the home for the seamen. The least expenditure—without care as to whether the character of the seamen was being raised or lowered by the provision made for his comfort—this one would expect to find the ruling consideration.

So ships and men, by force of trade rivalries and state carelessness, have been allowed to move on a level far below the dignity of their calling. In permitting it the state has allowed its own right arm to be gradually paralysed. The flagrant inefficiency of the great mass of iron and steel shipping in the matter of bulkhead subdivision was carefully considered by a committee in 1890 and is dealt with later on in a separate chapter.

The total number of vessels belonging to the British Empire in 1899 was 34,896 of 10½ millions net tonnage. Of registered vessels in the United Kingdom, including the Channel Islands there were 11,167 sailing-ships of 100 tons net and upwards and 9,029 steam-ships of 100 tons gross and upwards. These ships were manned by 244,135 men of whom 33,805 were Lascars and 36,064 others were not British subjects.

Much has been said about the change in the char-

acter of the officers and men in state navies which is being brought about by the discontinuance of the use of sails. The author has seen the men of the British Royal Navy when they had no power but manual power in ships or in boats; they were assisted only by the wind and by the sea. They had learned in a hard school how to manage these forces. And the home on shipboard was as unlike the home of to-day as the duties of that pastime were unlike the duties of to-day. When the Naval Exhibition was held in London in 1891 an attempt was made to realise the home between decks of the sailors of the first part of the reign of Queen Victoria. For this purpose the "Victory" was rebuilt as she was in the early part of the century and the cockpit where Nelson died on the orlop deck of the "Victory" was reproduced. The small height between decks, the darkness at mid-day broken only by the light of horn lanterns, made people realise a little the cramped home of a former time. But these between deck spaces were palatial compared with those of the sailing twelve-gun brigs which were found in all the fighting and packet duties of a little over fifty years ago. The living deck spaces in these brigs where men ate and slept were only four and a half feet in height under the beams amid-ship and about four feet two inches at the sides of the ship. The sailors of that time endured hardness and it made them a race of heroes.

The table prepared by Mr. Laird Clowes already referred to shows how serious were the losses at the beginning of the nineteenth century in the best found ships; not losses so much from the perils of war but from the fight with natural forces. Shipwreck and fire were enemies that claimed their victims with appalling frequency. Now it is a rare thing for a ship-of-war to be lost by storm or by fire.

CHAPTER IV.

MATERIALS AND LABOUR.

On the 25th of July, 1842, there was launched into the Medway from Chatham Dockyard two ships, both said to be "of fine models and built upon the recently improved principles of naval architecture." One was the "Goliath," 80 gun line-of-battle ship, and the other was the "Virago" steam war-frigate.

The officer who superintended the construction of this "Goliath" was Mr. John Fincham, then master-shipwright at Chatham. He published in 1850 a *History of Naval Architecture* or *Shipbuilding*. The present writer little thought when he witnessed the launch of these ships that more than half a century afterwards he would undertake, in brief outline, the continuation of the history, and would refer in the course of it to another "Goliath," battle-ship, 390 feet long instead of 190; of 13,000 tons weight instead of 3,600 tons, and designed to steam at 18$\frac{3}{4}$ knots instead of looking for a supreme speed of 12 to 13 knots, under sail, in favouring winds. Still less could he have supposed that instead of the three feet thickness of plank, and rib, and truss of solid oak, which formed the sides of the former ship, he would have to defend the use of an iron skin, stretched over skeleton ribs, not more than a mere fraction of an inch in thickness.

The frame of the earlier ship had been built of naturally curved timbers of Italian and English oaks. Her inner planking and trussing were of English,

African, or Dantzic oak; and this structure, apart from the outer planking, had been formed into a compact solid water-tight structure, which, even unplanked, would have floated securely. The outer planking of oak, or of elm, had then been fastened over all with oak treenails and copper bolts.

She had been built by shipwrights, aided by sawyers, blacksmiths, joiners, millwrights, and caulkers. Shipwrights had fashioned wooden moulds in the mould-loft for cutting out and trimming the timbers to agree with the curves and lines of the "drawings of the ship;" they had trimmed the timbers and planks with axe, adze, and plane; they had made moulds for all the iron forgings; they would make her masts and yards and boats.

Her timbers and planking would now be useless; the art of preparing moulds for them is practised no longer. Even the boats which the ship carries are now steam vessels; and the art of wooden mast-making is a lost art in H. M. Dockyards. The shipwright himself has well nigh vanished. There are still men bearing that name and using axe, adze, plane, and auger, but outside the Royal Dockyards the shipwright has no longer anything to do with building the structure of the ship. The art of shipbuilding has passed into the hands of platers, riveters, caulkers, fitters and other workers in iron and brass, and their Unions have shut out the shipwright. The Shipwrights' Union now only claims to make moulds, to fair the framing by ribbands, to make and break stages, to lay decks, to lay blocks, and to launch ships.

Boiler makers now call themselves iron shipbuilders, and engineers undertake all ship fittings.

The divisions are as follows:

Iron Shipbuilding.—Plating in all its branches, including boiler making, riveting, chipping and caulk-

ing. Holders on (for hot work only). Angle Smithing. Frame bending.

Drilling.—The drilling of all work other than machine-work. Tapping holes for purposes connected with shipbuilding.

Hammer-men.—Working with smiths only. Those working with frame benders and platers, while very useful with a hammer, are precluded from styling themselves as hammer-men.

Shipwrighting.—Mould-making, ribbanding and fairing, making and breaking staging, laying blocks and launching, also decking.

Engineers.—Including, besides pure engineering, all ship fitting such as deck fittings, anchor and steering gear. The general smiths, and also engine smiths, are incorporated with the engineers.

The new "Goliath" will be produced from keel to masthead by methods and by tools with which the makers of the old "Goliath" would have been as unfamiliar as children; and of materials not known to them. Instead of the pleasant scents of the timber and vegetable tar, and the sounds of axe, adze, saw, and maul to accompany the slow upbuilding of many years; there will be the smoke of rivet fires, and the ceaseless din of platers and riveters for a few fretful months. The frames and diagonal trusses and planks of oak, and the stately spars of pine and fir will be useless; dowells and treenails of oak, and yard long bolt-staves of copper, ringed and clenched at head and point, will be no longer known. Mild steel frames and plates and rivets, hardened steel armour, and steel castings and forgings will take their places; and all this within one splendid reign in Great Britain.

But the changes have not been made without much misgiving. When England had ceased to build wooden ships-of-war a vice-admiral commanding

the Channel squadron told the present writer that he feared the French were right in continuing to build their armoured ships of timber instead of thin iron. When the first steel-bottomed ship-of-war went into the Mediterranean it was held in the navy that a mistake had been made; that the salt water was rapidly destroying the plates and that they were too thin.

The difference in cost of production is not less striking than the difference in materials and in methods. For the £80,000 of the early "Goliath" we have to substitute twelve times that amount in order to produce the later one.

A word here as to the subsequent history of the two ships launched on that July day in 1842 may not be out of place.

The "Goliath" when launched was put in "Ordinary." She was moored in the Medway until it might be decided to fit her for sea. But as a sailing line-of-battle ship she never was so completed. For fifteen years she lay in "Ordinary" in charge of shipkeepers, who were old sailors or old marines, and lived on board with their families.*

In 1857 it was decided to convert her into a 60-gun screw ship, and she was completed accordingly in 1858. She was one of the ships which had caused Navy Estimates to go up to $8\frac{3}{4}$ millions in 1858, and led to Lord Derby's Committee of that year. Five years afterwards she was reported to be useless, and she was again laid up in "Ordinary" or Steam Reserve from 1863 until 1870. In 1870 she was lent to the Managers of the Forest Gate School District, and in 1875, while serving as a school-ship on the Thames, she was destroyed by fire.

The steam war-ship "Virago," launched on the same

* See appendix II.

day as the "Goliath," survived her by one year. She was taken to pieces at Chatham in 1876.

The "Virago" had been engined by Boulton and Watt. Her displacement was 1,669 tons; the indicated power of her engines was 546 horses, and her measured mile speed was 8 knots. After various services at home she was commissioned for the Pacific Station in 1851. She was recommissioned, after repair, in 1861 for North America and the West Indies, and was paid off in 1865. In 1866 she was again commissioned for the Australian Station, and was paid off in 1871 to be finally taken to pieces, as has been said, in 1876, in the yard from which she had been launched thirty-four years before.

The weight of the hull of such a ship as the "Goliath" was rather more than half the total weight of the ship and her equipment. Her weights were made up as follows:

	Tons.
Hull	1,882
Masts, yards, rigging and sails	175
Guns, powder and shot	348
Fresh water	383
Water tanks and iron ballast	247
Provisions, coal and wood	320
Anchors and cables	84
Boatswain's, carpenter's, and gunner's stores	79
Boats and their gear	10
Men and their effects 675	78
	3,606

The materials of which the hull was composed are given below. The average weight of timber materials in the ship is taken at 50 pounds per cubic foot, and that of the masts and yards at 40 pounds per cubic

foot. It will be understood that it was not the practice to weigh the wood materials which were employed, but to measure them and then take an average weight, at the average point of dryness or seasoning.

	Tons.
Timber	1,654
Iron	119
Copper bolts	40
Copper sheets and mixed metal nails	17
Lead and brass	10
Oakum, pitch, tar and paints	42
	1,882

The average number of oak treenails in this class of ship was 35,000.

The cost of the ship was made up in the following manner, at war rates—

	£
Materials in the hull	53,390
Cost of masts and yards	3,506
Rigging and blocks	[illegible]
Furniture and stores	15,000
Shipwrights' labour*	9,435
Joiners' labour	1,196
Smiths' labour	721
Caulkers' labour	446
Painters' labour	[illegible]
	[illegible]

* Here Shipwrights' labour is nearly 79 per cent of the whole labour.

In building (1893) H. M. S. "Speedy," which cost nearly the same amount to her builders, not a single shipwright workman was employed.

The amounts were lessened in time of peace. Peace rates were 20 per cent lower for labour, and 18 per cent lower for materials.

At the commencement of the reign of Queen Victoria types of shipbuilding for war purposes were considered to be so firmly established that Mr. John Edye F. R. S. assistant surveyor of the navy, was encouraged to publish a set of tables giving detailed information as to the several classes which properly constituted the navy. These were the 120 gun ship, 80 gun ship, "Goliath" type, 74 gun ship, 50 gun razée, 52 gun frigate, 46 gun frigate, 26 gun razée corvette, 28 gun frigate, 18 gun corvette, 18 gun brig, 10 gun brig, schooners and cutters.

In the "Goliath" class the main lower yard was 104 feet long; the areas of the main course and of the main topsail were 5,000 square feet in each; and the total area of the principal sails was 27,600 feet.

The number of loads of timber required to build the ship was 4,340.

The material of which vessels are now constructed, both for commerce and for war, is steel. If it were desired to build a vessel of iron now, the desired material could hardly be found in the market. But between the years 1866 and 1876 only three small vessels were registered at Lloyd's as built of steel. The real start was made for merchant ships in 1878 when eleven vessels were built of steel. Out of a gross tonnage of 574,819 tons classed by the committee of Lloyd's Register in 1878, 52,657 tons were of wood, 517,692 of iron, and only 4,470 of steel.

The difference between iron and steel, as employed for shipbuilding purposes, may be said to be that steel is iron which has been got into a molten condition, thoroughly cleansed, by great heat, from its alloys

and has then been definitely re-alloyed with chosen alloys, usually carbon and manganese, in such proportion as may be needed to give it strength and other desired qualities. The quantities of the carbon and of the manganese or other alloys may be very small; the carbon may be about one-tenth per cent; i. e., one thousandth part of the whole, yet its presence or that of some efficient substitute is essential to give strength to the material.

The iron ship-plates of commerce, prior to 1878, were uncertain in quality, often unsound in structure, and generally either weak or costly, often both together. There was good iron to be obtained for the manufacture of boilers. Low Moor, Bowling, and Farneley irons were fairly uniform in quality and sound in structure (although bad laminations were not unknown), but such boiler-plate cost £44 per ton, while the plates for building merchant-ships, in use at the same time, up to 20 feet long, 4 feet wide, and 9 cwts. cost £8. 17. 6. to £9. 0. 0. per ton. When the specifications required that every plate should stand tests to be imposed on delivery, or under inspection at the works, tests which were very moderate, and had been accepted by the makers as reasonable, then the price per ton (as charged to the Admiralty) up to 7 or 8 cwts., at the iron works, was £19. 16. 0. per ton. Bessemer steel-plates of the same size cost, at that date, £21. 0. 0. per ton undelivered.

To explain the causes of these high rates for iron as compared with present prices it must be understood that in the manufacture of iron a varying and unknown quantity of carbon, phosphorus, sulphur, and silicon existed in the finished plate; and when the plate was tested, by bending strips cut from it, hot and cold, and breaking them by tension, no maker could

be at all sure of the result. A bad result in a sample might lead to a large rejection. Many rejections were also made on account of surface defects, and strong iron was especially subject to such defects.

The best custom in merchant ship-yards was to employ good and careful makers who branded their iron as a guarantee of good faith; but this by no means ensured good iron. Where the maker had good credit with designers, and builders, and surveyors, and could get his iron put into specifications he got good prices. What this credit was really worth in 1874-6 may be seen by noting the action of the Admiralty at that date. The present writer made the facts public at the time. They are repeated here in extended form because they have an abiding interest.

Purchases were made from various makers who were then supplying shipbuilding iron to private ship-yards. No information was given which could serve as a warning to the makers to be especially careful. The plates ordered were $7\frac{1}{2}$ cwt. each, the same specification and condition being given in all cases.

The plates delivered came out as follows:

Maker.	Qualities of Material.	Condition of Surface.	Cost per ton.
			£. s. d.
A	Strong, but harsh......	Two thirds unfit for use........	9. 13. 0.
B	Do.	Do.	9. 4. 0.
C	Strong and fairly ductile	Good.............	17. 12. 0.
D	Do.	One fourth unfit for use........	18. 2. 0.
E	Irregular in strength: fairly ductile.......	All unfit for use...	9. 13. 0.
F	Good..................	Good.............	22. 12. 0.

Maker.	Qualities of Material.	Condition of Surface.	Cost per ton.
			£. s. d.
G	Strong; fairly ductile ..	One sixth rejected.	12. 2. 0.
H	Weak, not ductile......	Good..............	19. 3. 0.
I	Fairly strong; ductile..	Good. One sixth defective......	9. 15. 0.
K	Strong and ductile. ...	Good..............	12. 13. 0.

In order of quality, not regarding surface defects which were only important as unfitting the material for outside plating, the plates stood as follows:

		£.	s.	d.	
(1)	D..............................	18.	2.	0.	per ton.
(2)	F..............................	22.	12.	0.	" "
(3)	I..............................	9.	15.	0.	" "
(4)	K..............................	12.	13.	0.	" "

The contract price of Admiralty plates of the same size, at this date, was over £20. per ton. Such plates were examined at the iron works by resident inspectors, and when passed by them were accepted and paid for. At the dockyards there were numerous complaints that bad materials were being employed in ships and in boilers, and a committee was appointed by the Admiralty in June, 1874, known as the Boiler Committee, to examine into the causes of certain cases of rapid deterioration in boilers. The committee consisted of two admirals and three naval engineers.

Without waiting for any investigation into boilers the committee at once condemned the ship-plates in use.

They reported on 24th of September, 1874: "We have found the iron plates supplied to Ports-

mouth dockyard to be very bad, and quite unfit to be used for boilers or ship-building, and it appears that this has been going on for some time past. The evidence we have received from witnesses called before the committee expresses a sad state of affairs. No time should be lost in making a change in the system of inspection of iron supplied for the navy."

It should be explained that inspection at the works had been substituted for inspection at the yards in order to avoid ruinous delays in examination and testing, sometimes followed by the rejection of hundreds of tons of material which had been in the yards for weeks awaiting the tests. The Portsmouth material condemned by the committee had been chiefly manufactured at the Atlas and Cyclops Works, at Sheffield. There need be no concealment of these names; they are proud names in commerce and cannot be hurt by this hasty and ill-considered condemnation. Were it possible to credit the statement of the committee then, it may be asked, what was likely to have been, at the same time, the character of ship-plates at £9. per ton which were being extensively used in the merchant ship-yards? The committee was reporting honestly, and to the best of its ability, but it was dealing with a difficult matter with remarkable courage, but with insufficient knowledge.

Three months later it was recommended by the committee that higher prices should be paid and the tensile test lowered: and that the manufacture of iron of first quality should be undertaken at Portsmouth or Chatham or both. Later still, when the steel now in general use was first being introduced into the navy, the same committee condemned it for use in boilers "under the present system of working with sea-water."

The Admiralty had by this time satisfied itself that

steel would eventually displace iron; that uniformly trustworthy iron made from a cast ingot would in the end displace the uncertain material produced by "puddling" in open furnaces and then "piling" and welding together these "puddled bars" to form plates. It was obvious that, with regularity and certainty of the results, cheapness of production must follow. Such a trustworthy material, known as crucible steel, was already in the market, but at prices which were prohibitive for shipbuilding.

It was Sir Henry Bessemer who had taken the step which made it possible to get steel at ship-building rates. He had succeeded in making a good marketable steel at reasonable prices. He was able to get in a few minutes, in a crucible of very large size, a heat sufficient to hold pure iron in a fluid state and drive off the alloys, in the form of gas and floating slag. He then added manganese and carbon, according to the quality required, and poured out into ingot moulds the quantity of material wanted for plates, to be subsequently rolled from the ingots.

Such plates had been used in building a few blockade-runners during the American War; and they had been used, to a very limited extent, for internal framing before 1870, in H. M. ships.

From no fault of the Bessemer process the plates delivered to the Admiralty by all the English makers were for some years uncertain in quality and the complaints from the Dockyards of the treacheries of the material were constant. The cause lay partly in the want of familiarity of the workmen with the peculiarities of the material and the need for special treatment.

The present writer saw every plate and angle bar which gave trouble at the yards and he is satisfied that,

apart from questions of treatment, steel was frequently supplied from all the best English works of a quality decidedly inferior to that which was making, at the same time at the Terre-Noire and the Creusot works in France by another process; viz. the Siemens.

Sir Wm. Siemens obtained his heat in a completely different manner. He employed a gas furnace in which, by admixtures of coal gas and air he obtained an inflamed gas of extremely high temperature which heated a bath of the molten metal instead of being driven through it. By the Bessemer process all the carbon could be driven out from a charge of five or six tons in from 20 to 30 minutes. In the Siemens furnace it required from eight to ten hours to do this. To these two men, Bessemer and Siemens, ship-building owes more than to any other persons who have aided it by their labours during the century.

In 1875 the author speaking at the Institution of Naval Architects, said:

"Engineers and ship-builders are, I think, generally of opinion that steel must eventually displace iron in ship-building, both for hull and machinery. I do not fully understand why the rate of progress towards this desirable end is so slow. Looking back ten years, I am disposed to say that (excluding armour plates) there has been no sensible progress in the ship-building material in actual use, whether of iron or steel, with the single exception of the introduction and partial development of the Whitworth process of compressing fluid steel. So far as our experience of it goes, the material produced at the Whitworth Works is as nearly perfect as can be imagined; but it is not yet fairly in the market, and the prices promise to be almost prohibitive to ship-builders.

No doubt excellent steel is produced in small quan-

tities by the converter and the bath at a much cheaper rate than it could be produced ten years ago; and, where the management is strict and careful, considerable quantities may be delivered of trustworthy material. Nevertheless our distrust of it is so great that the material may be said to be altogether unused by private ship-builders, except for boats and very small vessels, and masts and yards; and marine engineers appear to be equally afraid of it.

In October last, by the courtesy of the French government, I had an opportunity of seeing the iron and steel materials used in building the ships-of-war for the French navy. I am bound to say that not only was it, as far as I could see, of excellent quality, but there was an extended use of steel, which argued greater confidence in the material than we have ourselves. In the large new masted iron-clad "Redoutable," building at L'Orient, steel is being employed for the frames, the beams, the deck-plating, the bulkheads, the plating behind armour, and the inner bottom. There was thus only the outer bottom, and the rivets throughout the ship, from which it had been excluded. Two other large iron-clad vessels of war, the "Tempête" and "Tonnerre," designed by the same officer as the "Redoutable," were building at Brest and L'Orient, with the same distribution of material. About 600 tons of steel plates, made by the Bessemer and by the Martin-Siemens process, had been already used in these vessels, and of steel angles and double-tee steels 30,000 or 40,000 running feet had been worked into place. This steel had been produced mainly at Creusot and Terre-Noire.

Prior to the commencement of these vessels, in 1873, the use of steel in French ships had been limited to masts, boats, and very small vessels. Neither iron

nor steel had hitherto been used in the French national navy to any considerable extent. The only sea-going fighting-ships they have complete, built of other material than wood, are three in number; viz. the "Friedland," "Heroïne," and "Couronne."

The points of greatest interest to me were those connected with the mode of working the material. The use of iron hammers in bending it to form was scrupulously avoided, and the angle bars and double-tee frames were curved and bevelled by pressure, various devices for doing this having been initiated at L'Orient.

Speaking of the necessity for care in the manipulation of this steel, one of the French constructors said:—

"If it is impossible to work the plates without hammering, or without local pressures of great severity, or if the curvature given is considerable, it is necessary to proceed with care and skill to avoid ruptures in the course of the operation. The hammering ought to be done with light blows delivered over as large a surface as possible, and the curvature ought to be produced not at once but by successive stages. After the work has been done the plate should be promptly annealed." He says further, "One ought to avoid as much as possible partial or rather local heating. When by careful treatment the plate has been brought to its proper form, the annealing process should be immediately resorted to, and the heat should be applied very gradually, for a sudden augmentation of temperature in a point where the molecular tensions are already exaggerated might cause a rupture. When the plate has been regularly heated to a sufficient temperature, and is left to cool slowly, the bad effects

of the local disturbances will be destroyed and homogeneity will be re-established."

The heating furnace used is a Siemens gas furnace, and the plates are generally allowed to cool upon the floor of the shop, taking care that it is dry, and that no part of the hot plate is allowed to come in contact with any rapidly-conducting material. I could not read the sentences I have quoted above without the reflection that a material which needed such care in its treatment would stand but a very poor chance in an ordinary ship-yard. I for one should feel very doubtful about a ship built of it for myself, unless I could see every plate worked.

The ordinary steel angles in use at L'Orient cost, I was informed, about £27 per ton, and the double-tee bars about £41 per ton. Add to this the cost of such careful labour as I have described, and it will be found that ships so built would be costly.

The author went on to say: "The uncertainties and treacheries of Bessemer steel in the form of ship and boiler plates are such that it requires all the care which has been bestowed upon it at L'Orient to avoid failure. The question we have to put to the steelmakers is, What are our prospects of obtaining a material which we can use without such delicate manipulation and so much fear and trembling? We have gone on for years using iron plates which are a compound of impure irons of different and unknown qualities welded together imperfectly in the rolls. We want a perfectly coherent and definitely carburised bloom or ingot of which the rolls have only to alter the form in order to make plates with qualities as regular and precise as those of copper and gun metal, and we look to the manufacturers for it. I

am ready for my part to go further than the French architects have gone, and build the entire vessel, bottom plates and all, of steel; but I know that at present the undertaking will involve an immense amount of anxiety and care."

On this Dr. Siemens said: "There can be no doubt that steel is a metal which is worthy of the highest consideration of ship-builders, engineers, boiler-makers, and all persons in fact engaged in construction of that kind. One thing is necessary, namely, that those who use that material should first know what it is. We hear of comparative results of steel and puddled iron as produced in one furnace and another furnace; and one would naturally come to the conclusion that steel was a definite compound varying only as regards quality. What is that compound may I ask? Steel in the form of a needle, an edge tool, or of a punch, is of a hardness approaching that of a diamond; steel in the form of a spring is of an elasticity unequalled by any other metal, or any other substance in nature. Then again steel in the form of a milled plate is, with few exceptions, the toughest material in existence—tougher than copper or wrought iron. It can be moulded into almost any shape in a cold condition. Therefore we ought first to understand what we mean by steel before we consider its merits or demerits for structural purposes. You may say that the hardness depends upon the proportion of carbon in the metal. Does it? I have lately experimented with steel containing four-tenths per cent of carbon. That steel, if treated in a certain way, would make an excellent punching or cutting tool. If treated in another way, and annealed carefully, it is so tough that you could work it into the form of your hat. Then again drawn into wire and

annealed in another way—that is to say, heated to a certain point and then put into oil—it assumes a tensile strength of very nearly 100 tons per square inch; whereas in the other form just before mentioned when annealed carefully its tensile strength would not exceed 35 or 36 tons. Now, if the mere fact of after treatment can produce such enormous changes in the behaviour of steel, how important must it be to give to steel the nature which we desire for structural purposes. Now if you take a plate and throw it down in a wet court-yard, and then punch it and use it for the manufacture of a boiler, there can be very little satisfaction in the result obtained from that material. Very likely in the same plate if you could cut out pieces you would find very different qualities, and some of these qualities would be valuable in one place and would be destructive to the plate in another. It may be laid down as a general rule that a higher material and a higher process requires higher intelligence to deal with it. If you ride a common cart-horse, you may go to sleep on him, but if you ride a fine-spirited horse all your wits must be about you, or else you may be landed in a ditch. So with steel, you have to understand first of all what quality of steel you have to produce, how much carbon and how much manganese should be mixed with the material, and how little sulphur and phosphorus you can put up with. Until you have done that you do not know what you are speaking of. It is a material belonging to a group varying between the hardness of a diamond and the toughness of copper; and it is also of the highest importance that the manufacture throughout, and the construction throughout, should be carried on with superior intelligence. Now should we shrink from using a material because intelligence is required

in working and using it? Surely that would be a very poor compliment to this age of progress. We should have no difficulty in finding what are the conditions necessary to produce steel of such and such a quality and should see to it that we obtain this quality and obtain it always. With regard to the question of obtaining it always, I maintain that we have a greater power in our own hands than with regard to iron: iron, as we know, is produced in small quantities; the puddler produces sometimes a ball which is rather young, and at other times produces it over-heated; and this material is piled again, put through the rollers, and in the end we get a sort of average between the qualities of the different balls. In making steel we formerly dealt with it in small quantities also by melting it in pots, but Mr. Bessemer has first shown us how to deal with it in large quantities in his converter. I have had considerable experience in dealing with it in large quantities in the open hearth furnace. There I know we can produce six, or eight, or ten tons of steel of perfectly uniform quality. We can take out samples before pouring that steel to assure ourselves of having the quality desired. This metal is thoroughly mixed —it is a perfectly fluid mass—and therefore there can be no reason why there should be a difference in the behaviour of one part of this metal from the behaviour of another part. Now I have lately seen steel of a very mild quality produced which is eminently suitable for structural purposes. This steel contains hardly any carbon at all—perhaps one-tenth per cent only; but it contains manganese in a larger proportion than has been given to it hitherto. It is possessed of a toughness which is unapproachable by any other kind of metal; and before it breaks it yields even to 50 per cent. Now if such a material can be produced,

and if such a material will resist, say 30 tons, which is quite enough for all purposes, I think that it is the very best material for structural requirements."

The result was a contract with Dr. Siemens for steel for the despatch vessels "Iris" and "Mercury" and the general introduction of steel as the ship-building material in the Royal and Mercantile Marine. So late as November, 1879, the Surveyors of Lloyd's found difficulties with open hearth steel but they soon disappeared.

The present price of ship-plates is about five guineas per ton exclusive of delivery, which would be about another half guinea per ton. Angles, teebulbs, z-bars, and tees average about the same, angles and angle bulbs being a little less per ton than plates, and tees a little more. The cost of the excellent steel of which our ships are being built to-day is thus only one-fourth of that of the best ship-building iron of 1878 an iron which, as has been seen, was inferior to steel both in strength and in soundness.

The saving in building a ship-of-war with 3,000 to 4,000 tons of such material, as compared with the prices of 20 years ago, is very satisfactory to all except the favoured iron-makers of the earlier time.

* * * * * * *

Table showing the number, tonnage and description of new vessels classed by Lloyd's Register of British and Foreign Shipping and the materials employed during the year 1899.

	Steel.		Iron.		Wood and Composite.		Total.	
	No.	Tons (gross).	No.	Tons (gross).	No.	Tons (gross).	No.	Tons (gross).
Steam vessels.	583	1,283,274	77	14,441	4	607	664	1,298,322
Sailing vessels	9	14,957	...	....	14	2,190	23	17,147
Total.......	592	1,298,231	77	14,441	18	2,797	687	1,315,469

NOTE.—Parts of this chapter appeared in the London Graphic, September 30, 1899, entitled the Progress of the Navy, by the author with illustrations by the Marine Painter to the Queen.

CHAPTER V.

"ARMED SHIPS."

"For one thing this century will in after ages be considered to have done in a superb manner, and one thing, I think, only.

"It will always be said of us with unabated reverence '*They built ships of the line.*' Take it all in all, a ship of the line is the most honourable thing that man, as a gregarious animal has ever produced. By himself unhelped he can do better things than ships of the line; he can make poems and pictures, and other such concentrations of what is best in him.

"But as a being living in flocks, and hammering out with alternate strokes and mutual agreement, what is necessary for him in those flocks to get or produce, the ship of the line is his first work. Into that he has put as much of his human patience, common sense, forethought, experimental philosophy, self-control, habits of order and obedience, thoroughly wrought hand-work, defiance of brute elements, careless courage, careful patriotism, and calm expectation of the judgment of God, as can well be put into a space of 300 feet long by 80 feet broad. And I am thankful to have lived in an age when I could see this thing done."

John Ruskin,
Harbours of England.

The first iron-plated ships built for war service in modern times were the floating batteries designed for attacking Russian fortifications in 1854-5. The Emperor Napoleon III. in explaining the reasons for adopting them, urged the great cost of regular ships of war as compared with the cost of the fortifications attacked, and the magnitude of the losses to be feared in such operations if undertaken by large ships. There were two courses open to meet the difficulty. One was to employ ships protected by armour, the other would have been to mount the guns singly in gunboats, of which the loss of a part might be risked.

Unhappily for England, as the present writer thinks, and unhappily for herself also France chose armour plating. The Emperor desired protection for the crews against shell fire. Had he been a seaman he would never have chosen this alternative. It is contrary to all the seaman's instincts and especially to the instinct of the French seaman. Long after we in England had boxed up our gunners in armoured turrets, in imitation of Ericsson, the French seamen were firing their heaviest guns over the tops of their armoured gun covers or barbettes. The armour they said, was to protect the breech mechanism and the mountings of their guns, not the gunners. The gunners wished to see what they were doing. The Emperor himself, while in exile in England, is understood to have prepared a design for a first class fighting ship. In it he placed all the guns in the open, on the upper deck, without any armoured shelter above the axes of the guns. It must be said that quick-firing and Maxim guns had not then been adopted, nor melinite shells. The writer doubts very much whether, if they had been, the Emperor would have thought it more necessary to armour plate the

batteries against them than against common and shrapnel shell. Gradually the French have accepted the turret with guns fired through openings in the armour.

From the floating batteries the Emperor and his naval architects passed on to an armour-plated sea-going ship "La Gloire." She had a complete enceinte of 4-inch armour for her water-line and for her batteries. The instincts of the engineer, familiar with land fortifications, prevailed again over the seaman. The guns were fired out of port holes cut in the armour, port holes which had to be large enough to allow the gun to train through large angles and to elevate and depress; an arrangement which has had to be abandoned. The armour was moreover hung upon a wooden structure too perishable and too weak for such uses, as time has proved. The large use of wood in the French navy must have been forced upon the accomplished designer of the "Napoleon" and the "Gloire." M. Dupuy de Lôme was the earliest champion in France of iron in place of wood. In boldness of conception, and in executive skill he takes the first place among the naval constructors of our time.

No one in the British navy in 1859 appeared to doubt that we must follow the French lead. So the British government invited proposals from private ship-builders and from the master shipwrights of the Royal dockyards for designs for ships to match "La Gloire." It will be interesting to note the particulars of these various designs and to compare them with modern ships. All the designs were rejected except the last which was prepared at the Admiralty and which developed into the "Warrior."

DESIGNS PREPARED IN 1859 TO MATCH "LA GLOIRE."

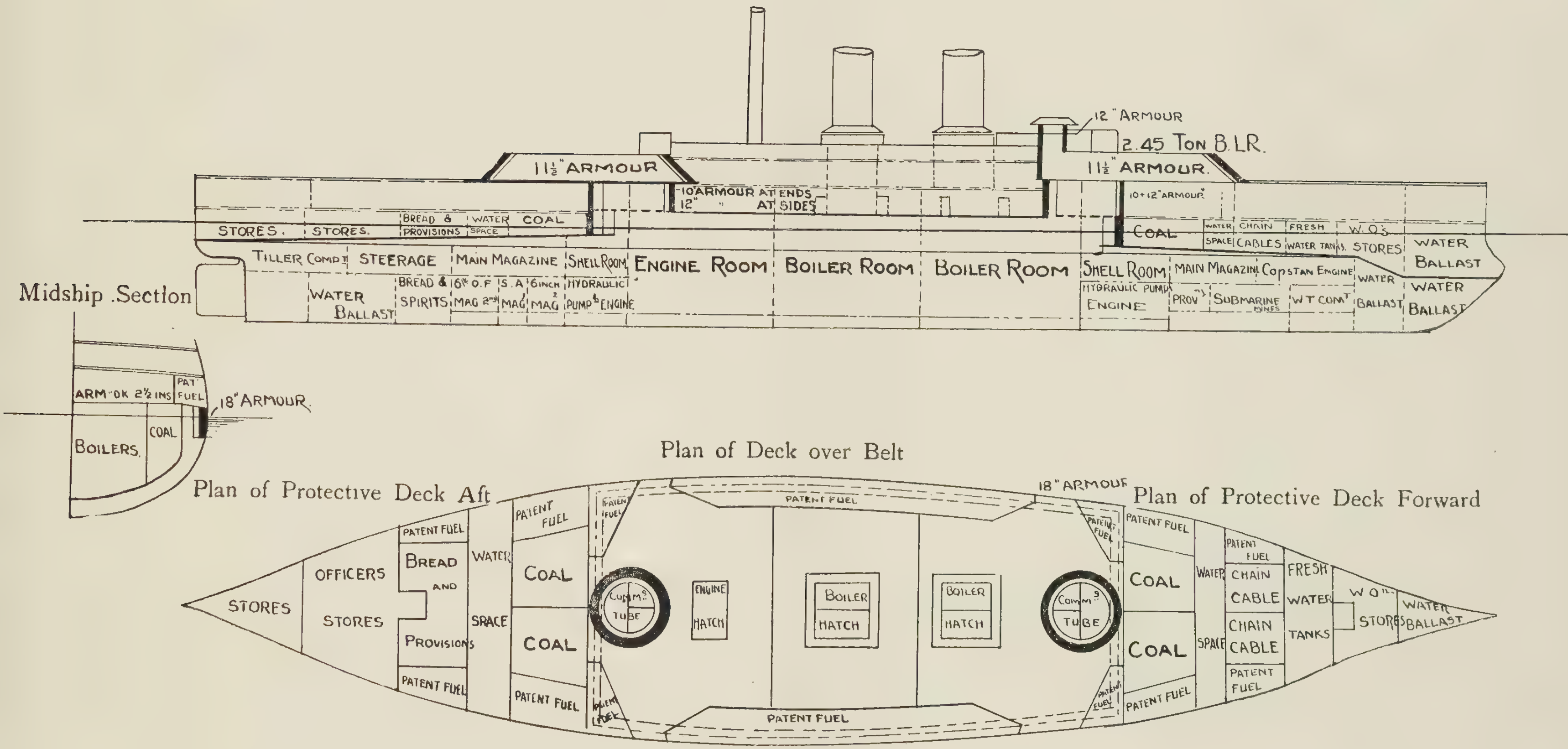
Designer.	Length.	Breadth.	Displacement. Tons.	Speed. Knots.	Wt. of Armour. / Displ.	Wt. of Hull. / Displ.	I. H. P. (of Engine).
Laird......	400.0	60.0	9779	13½	.11	.51	3250
Thames Co.	430.0	60.0	11180	......	.10	.58	4000
Mare......	380.0	57.0	7341	......	.13	.46	3000
Scott Russell	385.0	58.0	7256	.....	.18	.38	3000
Napier.....	365.0	56.0	8000	13½	......	......	4120
Westwood & Baillie	360.0	55.0	7600	13½	.16	.36	4000
Samuda ...	382.0	55.0	8084	13½	.16	.57	2500
Palmer....	340.0	58.0	7690	13½	......	......	4500
†Abethell..	336.0	57.0	7668	......	......	......	2500
Henwood ..	372.0	52.0	6507	......	.18	.4	2500
†Peake.....	354.9	56.0	7000	......	.14	.46	3000
Chatfield ..	343.6	59.6	7791	......	.14	......	....
Lang......	400.0	55.0	8511	15	.14	.53	2500
Cradock...	360.0	57.6	7724	......	.2	.42	2500
Admiralty, (Office)	380.0	53.0	8625	14	.18	.52	....

COMPARISON BETWEEN "WARRIOR" OF 1859 AND "COLLINGWOOD" OF 1884.

Ship.	Length.	Breadth.	Displacement. Tons.	Speed—Knots.	Wt. of Armour. / Displacement.	Wt. of Hull. / Displacement.	I. H. P. of Engines.
"Warrior"....	380.0.	58.4.	9,210	14.36	.15	.52	5470
"Collingwood" of 1884.......	325.0.	68.0.	9,200	16.5	*.26	.36	9570

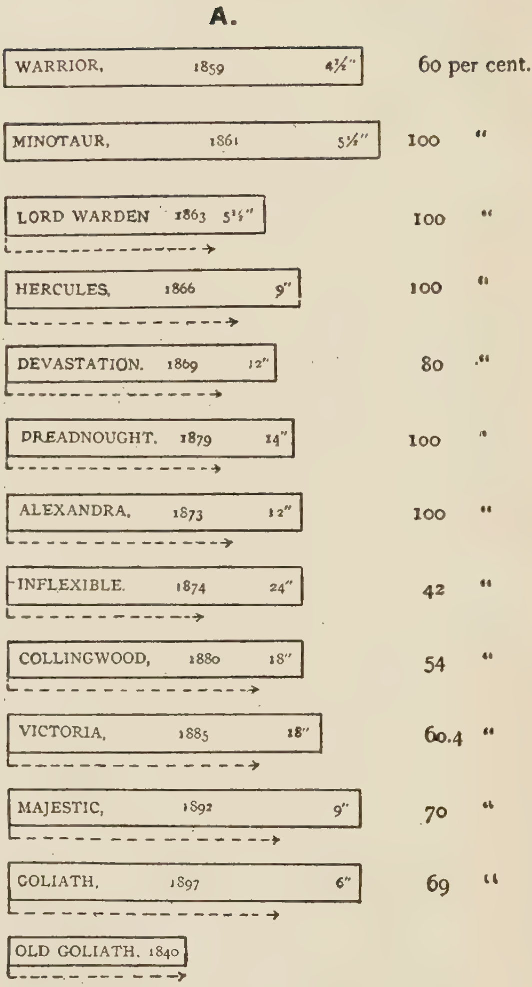
* With backing.
† To be built of wood

The "COLLINGWOOD"



Looking back from the "Collingwood" of 1884 to the proposed ships of 1859 we see that, with the same displacement as that actually adopted, there is an increase of over two knots in speed with a shorter and wider ship. It will be noted too that in the "Warrior" fifteen per cent of the total weight of ship is devoted to armour, and that this is also the mean proportionate weight of armour in the various designs. In the "Collingwood" twenty-six per cent is devoted to armour. The mean proportion of the weight of the entire ship and her equipment which it was proposed to devote to the hull was forty-seven per cent; the "Collingwood" is built, with a complete double bottom and great subdivision, with only thirty-six per cent of the weight of the entire ship and her equipment.

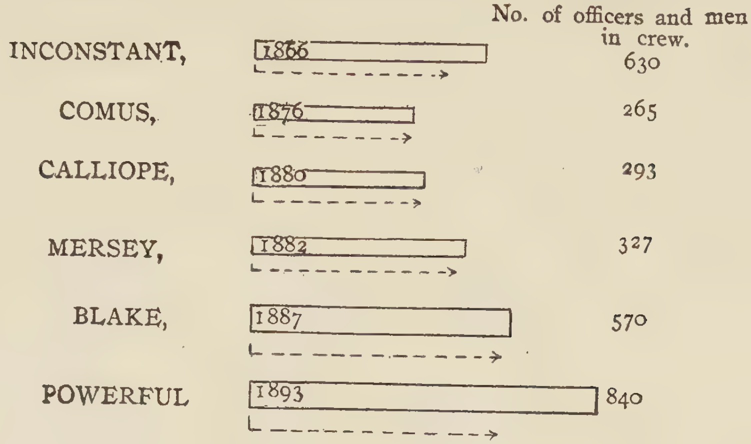
Diagram A shows the several important steps in successive years in the dimensions of first class ships-of-war. Attempts were made, and made successfully, to keep the dimensions of ships down in order to secure handiness, and to diminish the first cost and the upkeep of individual ships, and to avoid large crews. The diagram shows at first an increase in length in the "Minotaur" class. It was objected to them at the time that with a given thickness of armour, size of gun, and speed they were larger than the corresponding French ships and this was held to be defective designing. A third of a century later naval officers hold that there are excellent reasons why English ships of given speed, thickness of armour and size of gun should be larger than the corresponding ships of other nations. It is considered that more extended service is needed for British ships than for any others and that demands made by them for coal will be greater. It is held that these de-



Development of First Class Ships in Length, Displacement and Speed; Date of Design and thickness of heaviest side armour shown; also percentage of waterline area covered by side armour

B

Fighting ships without Side Armour, Length, Displacement, Speed, Date of Design and Complement.



NOTE.—All the above are protected by armour near the waterline, except the Inconstant.

mands are not to be expected to be met by protected coaling stations, or by coal transports, but by making each British ship carry more coal than will be carried by a rival ship of equal fighting ability. If these principles had been accepted by the Controller of the Navy in the early sixties designing would have been much modified. The "Minotaur" marked the high water of the designs of Mr. Watts and he was blamed by the Controller of the Navy for the supposed extravagance of her dimensions as compared with contemporary French designs.

The building of the "Warrior" commenced 25th May, 1859. In her, the "Black Prince," the "Achilles," "Defence," "Resistance," "Hector," and "Valiant," the iron armour was thick enough to keep out all the explosive projectiles of the time, which did not enter by the gun-ports.

In all these ships the battery determined the enceinte of the armour, the water-line put in no claim to determine it. But before the "Achilles" was completed the dangerous exposure of the steering gear in these single screw ships forced itself into notice. The tiller was necessarily above the water-line and was outside of the cover of the armour. The wooden line-of-battle ships, with which the designers of these first iron-cased ships were familiar, had required no special water-line protection, and when wheel ropes or tiller were shot away the ship did not cease to be able to fight. The line-of-battle ships, which they knew so well, had a lower or gun deck about four feet above the water-line, and an orlop deck about three feet below the water-line. Between these two decks the ship's sides were stouter than in any other part, and shot did not easily perforate them. When a shot did enter there, between wind and water as it was called,

ample provision was made to prevent the serious admission of water.

In this between-deck space the sides of the ship were kept free from all erections or obstructions. The "wing passages" on the orlop were clear, from end to end of the ship, and they were patrolled by the carpenter's crew who were provided with shot plugs of wood and oakum and sail cloth with which to close any shot holes. As against disabled steering gear there were spare tillers and tiller ropes, and only injury to the rudder head itself was serious. But a steam-ship, built of iron, and having only a single propeller was very different. Such a ship must keep control of her steering power; and shot holes between wind and water at the ends of the ship might create inconvenient changes of trim. So the "Achilles" was not completed like the rest of these ships, with most objectional water-line features at their extremities; she was armour-plated, under the advice of Sir Edward Reed, throughout the length of the water-line; and a larger displacement and increased draught of water were accepted for her. These objections had been realised by the designers of the earlier ships, and the "Minotaur" class, which commenced building 12th September, 1861, was plated from end to end at the water-line, and nearly from end to end in the batteries. Although these ships of 1861 were so large none of the armour was thicker than 5½ inches.

In the chapters on armour and guns the progressive steps in the contest between them will be seen.

In diagram A, the only wooden armour-plated ship given is the "Lord Warden." But a number of similar ships were converted or built. They were all armour-plated throughout, and they have all disappeared from the Navy List. They were as follows:

Ships.	Displacement.	When Commenced.
"Repulse"	6190	1859
"Royal Alfred"	6700	1859
"Zealous"	6100	1859
"Caledonia"	6830	1860
"Ocean"	6830	1860
"Prince Consort"	6830	1860
"Royal Oak"	6370	1860
"Lord Clyde" and "Lord Warden"	7840	1863

In the ships named below the thickest armour on the sides of the ships and the heaviest gun carried are shown. In the "Majestic" and "Goliath" there is thicker armour on bulkheads and on gun positions than there is on the sides of the ship, and the armoured deck within the ship lies behind the side armour at the wings, and is from three to five inches thick.

Date of commencement of ship.	Name	Thickest armour on sides of ship. (Inches.)	Heaviest gun.	Displacement. (Tons.)
1859	"Warrior"	4½	9 ton M. L.	9210
1861	"Minotaur"	5½	12 "	10690
1863	"Lord Warden"	5½	12 "	7840
1866	"Hercules"	9	18 "	8680
1869	"Devastation" (no sails)	12	35 "	9330
1870	"Dreadnought" (no sails)	14	38 "	10820
1873	"Alexandra"	12	25 "	9490
1874	"Inflexible" (auxiliary rig)	24	81 "	11500
1880	"Collingwood" (no sails)	18	45 ton B. L.	9200
1885	"Victoria" (no sails)	18	110½ "	10470
1893	"Majestic" (no sails)	9	46 "	14900
1897	"Goliath" (no sails)	6	46 "	12950
1897	New armoured cruiser	6	27 "	11850

The justification for the reduced thickness or armour in the most recent ships is given in the chapter on armour and guns.

It was decided when the "Devastation" was designed in 1869, as an unmasted ship, to give her twin screws. This arrangement gave such good results in her, and in the "Thunderer" and "Dreadnought," which followed her, that it was determined to fit the masted ships "Nelson" and "Northampton," designed in 1874, with twin screws. Having got rid of the central propeller in these ships it was seen to be possible to lower the tiller and to keep it and the rudder head under cover of an armoured deck, and to place the deck itself five feet beneath the water-line. In the "Shannon," a single-screwed ship, of small comparative size, which had preceded these ships by a year, the forward portion of the armour belt had been suppressed, as in the "Warrior."

The advantages gained by this suppression were the avoidance of the thinned-down belt armour, which had been always given to the extremities of the belted ships; and the substitution of a strong and submerged deck for the thin and exposed deck which had hitherto formed the top or cover of the belt at the extremities.

The strong submerged deck was made to form a horizontal web for the ram, to support it laterally when striking. This form of ram has been continued in British ships. The unarmoured spaces in the fore part of the "Shannon," into which water might enter were too small to injure the ship seriously if they were flooded, and the spaces liable to be flooded were cut up into small store rooms, partly occupied by water-excluding stores. In this an attempt was made to carry out in some measure the recommendations of the Committee on Designs of 1871. An extension

of this principle marks all the succeeding ships having side armour designed between 1874 and 1885, except the so called belted cruisers of the "Undaunted" class.

In the "Nelson" and "Northampton" for the first time the raft body at both ends of the ship was adopted. By this arrangement and by lightened hulls these ships were made to compare not very unfavourably with earlier masted ships of much larger size. The comparison between the "Nelson" and the "Hercules" stands as follows:—

(The "Hercules" with a closed battery has always been regarded with favour in the navy as a well-designed ship. The open battery of the "Nelson" armoured at the ends, and subdivided by bullet proof screens into smaller separate gun emplacements has been much criticised.)

	"Hercules"	"Nelson"
	Ft.	Ft.
Length	325.0	280.0
Breadth	59.0	60.0
Displacement in tons	8680	7630
I. H. P. of engines	6750	6640
Speed at m. m. (knots)	14.7	14.05
Max. thickness of armour (ins.)	9 ins.	9 ins.
Total wt. of armour (tons)	1695	1720
Guns of 9 tons and upward	8 10 ins. 2 9 ins.	4 10 ins. 8 9 ins.
No. of officers and men	630	550
Area of sail in sq. ft.	28,800	24,770
Area of sail: (displacement)$^{\frac{2}{3}}$	68.6	64.3

The "Devastation" of 1869 not only inaugurated twin screws in the navy: in her also the absence of sail power in a sea keeping ship-of-war was tried for

the first time. With this was associated low side free board (following the lead of the "Miantonomoh"), and turrets. By the use of revolving armoured turrets, originated in the United States, and developed by Capt. Cowper Coles in England, it was possible to increase the weight and power of the gun, and to pass from the guns of 18 tons to guns of twice that weight, and more.

Such turrets were in use in 1869, in the "Royal Sovereign" and "Prince Albert," fitted under the superintendence of Captain Coles. Besides these unmasted ships, two masted ships were already building, the "Captain" and the "Monarch"; one designed by Messrs. Laird of Birkenhead, under the uncontrolled superintendence of Captain Coles; and the other, designed at the Admiralty, under the Controllership of Sir R. Spencer Robinson. (For further particulars as to turrets, see Armour and Guns.)

The boldness of the design of the "Devastation" was remarkable. It was so novel that before the ship was tried at sea it was universally distrusted by the navy, and held to be unsafe. These evil surmises grew largely out of the loss of the "Captain" on the 7th September, 1870, by capsizing under sail at sea. The "Captain" capsized because she had a low side freeboard. The side of the freeboard of the "Devastation" being still lower it was held that she must therefore be an unsafe ship. She could not, clearly, be capsized by her canvas, for she had none, but she would certainly be overwhelmed by the sea. This was the general naval opinion. But the navy did not distinguish between two very different uses of "freeboard." Height of side out of water is required in a sailing-ship, where the sails are secured, and cannot be immediately loosed in a squall, in order to provide

a margin of stability to right the ship from a sudden heel. A high side is even more influential than a broad beam in giving this margin of stability.

In an unmasted ship, with great beam, high side freeboard is not only not required for this purpose, it is an evil, because it will set up quick and deep rolling among waves. The American monitor "Miantonomoh," although in no sense a sea-keeping ship had crossed the ocean and visited Europe, and her side freeboard was only three feet. She had a very large initial stability, her metacentric height being 16 feet. With such stability there must have been extremely troublesome and dangerous rolling had the side freeboard been high. It was reported that there had been on the contrary a remarkable immunity from rolling, an immunity evidently attributable to the absence of a high side and to the fact that the deck was often awash. It was probably the behaviour of this ship which led to the proposal to give to the "Devastation" only 4½ feet freeboard along her sides and after deck. But freeboard has another use in all ships. It is necessary for keeping the sea out of the openings in the deck. The "Monarch," masted turret ship, had these openings eleven feet out of water, while Captain Coles had contented himself with eight, and only secured eventually between six and seven. It was considered by the Admiralty that this eight feet was insufficient for "hatchway freeboard, that there ought to be at least ten feet, and in the "Devastation" although the "side freeboard" was so much reduced, a hatchway freeboard of eleven and a half feet was given.

The "Devastation," with some alterations recommended by the Committee on Designs, was eventually completed for sea after her designer and the Con-

troller of the Navy had left the Admiralty. Neither of them was satisfied that the ship had been properly completed for sea. The entire navy, outside the Admiralty, and highly placed persons at Court held that to send such a ship to sea, would be criminal.

Mr. William Froude, to whom, and to whose able son and successor the navy owes an immense debt of gratitude, supported the Constructors of the Navy in their contention that the ship would be as perfectly safe in any weather at sea as a ship can ever be. The results at last justified the designer, Sir Edward Reed, and not less those on whom the completion and equipment of the ship fell.

But long after the success of the ship in ordinary weather at sea had been proved it was held in Parliament and in the Press, that the low hatchway freeboard forward and aft, and the peculiar form given to the after end of the unarmoured side structures, the "*cul de sac*," were dangerous features in a seagoing ship. There was no sound foundation for these objections but they were very influential in determining the form of the upper works of the large armoured ship designed in 1874—the "Inflexible," and high hatchway freeboard was given to her from stern to stern. This made it necessary to place the turrets *en échelon*.

In 1874 the whole aspect of the question of armour had been modified by the recommendations of the Committee on Designs of 1871 having been adopted by the Italian designers in the first class ships "Duilio" and "Dandolo," which were the precursors of the "Inflexible" in the shortening of the armoured enceinte or central citadel. This had already been done, as has been seen, in England in the "Nelson"

design, but the adoption of the views of the committee in a first class ship was another matter.

In these ships, moreover, there were to be guns of 100 tons each, and, they were to be loaded at the muzzle. This meant that they must be loaded outside the turrets. In the "Devastation" the guns were in length only half the diameter of the turrets, and they could be depressed within the turrets for loading; but the new guns were longer than the outside diameter of the "Devastation's" turrets. The adoption of the suggestions of the Committee on Designs had also enabled the Italian constructors to employ armour for the defence of their citadels 22 inches thick, or nearly twice the thickness of the maximum "Devastation" armour. Unhappily English designers were in the same position as the Italians in the matter of guns; the British Ordnance Department would not make breech-loading guns but adhered to muzzle-loading.

The Committee on Designs had not only made fruitful suggestions as to concentrating the armoured enceinte; they had made recommendations as to naval centres which required ships of great power, but which had no connection with racing at naval manœuvres.*

* "We believe that our transmarine possessions and other important interests in distant parts of the world, will be more efficiently protected by the establishment, where requisite, of centres of naval power, from which vessels of the "Devastation" class may operate, than by relying upon cruising ships of such limited fighting power as the "Monarch."

"As powerful armament, thick armour, speed and light draft cannot be combined in one ship although all are needed for the defence of the Country, there is no alternative but to give the preponderance to each in its turn amongst different classes of ships which shall mutually supplement one another."

It should be said that the thickness of the armour employed in Italy, 22 inches, was considered to be about the measure of the power of the 100 ton gun to perforate the plate. In the trials of December, 1876, at Spezia this was confirmed. A 22 inch Sheffield plate was struck by a 17 inch projectile with a velocity of 1,500 feet per second. The projectile struck over a frame, broke it, and turned it up beyond a right angle, tore through the skin plating, and drove fragments of the plate and backing through the skins. It drove a bolt about 8 feet to the rear of the target.

These were the circumstances in which the design of the "Inflexible" was prepared. The designers had a certain standard which they had laid down for themselves, as being applicable to all ships of war, whether they are said to be armoured or not, and whether battle-ships or cruisers.

They said, "there should be the greatest possible offensive power, and the defensive arrangements should be such as to ensure the ship, as far as possible, and in equal degrees, against all the various modes in which she may be disabled or destroyed. From this it will follow that it should not be in the power of the enemy to disable the ship by one single blow delivered by any means at his command, if this could have been prevented by causing other defences, where he has not this power, to surrender a portion of their strength to succour the weak part."

In a well-designed ship there should be defence for the propelling power, for the steering power, and for the floating power against the gun, the ram, and the torpedo. To a very large extent, they said, the defence against the last two named, the ram and the torpedo, must rest with the officer in command. But to resist them he must retain command of speed and

steering gear. He therefore requires that these and the floating power should be equally defended against the gun, which he cannot avoid. The avoidable weapons are provided against, by material defences, far less than is the gun which cannot be avoided. The equality of defensive power in view of all these weapons is obtained by reckoning as a part of the defence against the ram and the torpedo the skill of the seaman.

The application of these principles to the design of the "Nelson" will be seen in the duplicated screws, the sheltered steering gear, the long and open battery, the suppression of thin belt armour and of thin decks covering it at the extremities of the ship.

The question may be asked, did the "Inflexible" embody these principles?

Her design was absolutely ruled by the muzzle-loading guns, and the offensive power of the ship suffers by the slowness of their fire. The speed of the ship is a main element in the offensive power, and under the conditions laid down for her sphere of operations, 13 to 14 knots was regarded as sufficient. Another question is, are the principles which have been referred to sound? It will be seen that they assume the gun to be unavoidable. The torpedo boats therefore fall out from their application. The first principle with them is and must be to avoid the gun.

If for ships the gun is unavoidable, and if it is capable of perforating the ship's side armour, then a single blow may be fatal, and a ship so armoured and exposed to such guns ought to have superior speed to enable her to choose her range. Ships defended only by horizontal armour, like the "Powerful" and "Terrible," are thus far less likely to be fatally injured by

a single blow from a gun than is a side-armoured ship; yet the side-armoured ships are the slower.

If these principles are sound, perforable side armour has grave disadvantages; yet it is widely used in all navies. It has its value as a defence of stability under prolonged gun fire, but it is not regarded as indispensable for this purpose, as the adoption of the large types of heavily armed ships without side armour, such as the "Blake" and "Powerful," shows.

The question of the influence of side armour on stability has been much obscured by partial statements in parliament and in the press. They were partial statements because they concerned a subject not easily presented fully to the House of Commons or to the public generally. The writer may fail in the attempt he is about to make to state the case fairly and clearly, but he will do his best.

Although armour on the upper parts of a ship raises the centre of gravity of the ship, yet the proportions and form of the ship can be so adjusted that she may behave perfectly, in any weather at sea, while she may have from three to four thousand tons of armour attached to her, above her middle.

As against the attack of guns, armour on the ship's sides in the region of the water-line has a great advantage in preserving buoyancy. If it protects the entire water-line against perforation then the ship cannot be sunk by horizontal gun fire.

In "protected" ships (i. e., ships protected by armour within them, and not upon their sides) perforation by shot and shell in the neighbourhood of the water-line has to be expected. In that case the amount of water may be limited by making the water-line region solid or nearly solid. A water-tight deck is formed a few feet below the water, and an-

other a few feet above it. The space between has many partitions, and in the compartments there are stores, coals, or other resisting and water excluding materials which limit the admission of water through the shot holes.

If water enters in large quantities and can move freely within the space between the two decks the ship will lose stability just as she would if the same water had not been stopped by the water-tight deck, but had flowed into the hold and washed about freely there.

All "protected" ships are defended throughout their whole length in this way. Ships with short belts, like the "Admiral" class, are defended partly in one way, and partly in the other.

There is a partial belt of very thick armour, practically impenetrable, and this covers magazines and machinery. Beyond the belt there is the "protected" ship arrangement. The buoyancy would be better protected if the impenetrable armour extended from stem to stern, but it would not be so well protected, if in spreading the armour out further, and thinning it, it lost its impenetrability.

When water enters a ship in sufficient quantities the ship founders. In a ship not divided into compartments the entrance of water through wounds under water or through portholes or hatchways or cabin scuttles will cause her to sink keel downwards at first. Even if the water is deep; if the ship is masted, she may not turn over in sinking, although she may be top heavy, by reason of armour or guns. But an armoured ship, unmasted, would in deep water turn over before she reached the bottom.

Where a ship has a protecting deck at or beneath the water-line and has no open ports, or scuttles, or

hatches through which water can enter freely to the holds, then the admission of water in large quantities into the protected space at the water-line must cause her to turn over before sinking, unless the double bottom compartments have been voluntarily filled in order to lower the centre of gravity. It is conceivable that capsizing before sinking may thus be sometimes averted, and seamen ought to know what can be done by the admission of water in order to avoid dangerous alterations of trim and to limit the inclination caused by wounds under water or at the waterline. Water moving freely on the double bottom is a capsizing force: water shut up in the double bottom, the compartments being filled, and not partly filled, resists capsizing. The modern ship of war whether protected or armoured is in danger of capsizing, when wounded under water, to an extent unknown fifty years ago. First, water is carefully shut out from the lower parts of the ship. It cannot enter through port holes; and when the wound admits water to an under water compartment the water is not allowed to spread from stem to stern, as it could in the wooden ships. In them the bilges, as they were called, were continuous water courses from end to end of the ship.

Secondly, although some of the older ships were lofty and top-heavy, they were masted with immense masts and yards of pine, and, these by their buoyancy corrected the top-heaviness when the ship was foundering and would probably keep her keel downwards while sinking. The increased risk of capsizing before sinking in the wounded ship of war of to-day is not peculiar to any class, or to any navy. Instructions are sometimes drawn up, and entered in the ship's books, to guide officers as to the uses of the extensive flooding arrangements in their ships; but more than

this is needed. Officers should have practical demonstration of the effect of wounds *through* the armour, and *beyond* the armour, and *beneath* the armour, and thus learn how much and how little the costly and elaborate arrangements for flooding and for pumping are worth. They should learn, too, just what they may expect in "protected" ships, having no side armour, when they are wounded at the water-line.

The "Inflexible" was followed by other turret ships designed for large muzzle loading guns, and all with armour arranged on the same plan. It was exceedingly thick over vital parts and was suppressed where it could be replaced by the protected system. There are in these ships side armoured middles and protected ends. The "Ajax" and "Agamemnon" are of the same displacement as the "Hercules;" the "Colossus" and "Edinburgh" about the same as the "Devastation."

The two former ships were designed for 13 knots measured mile speed and they represent the theories of the time as to the advantages of great breadth in warships. It would not have been considered safe to expect even this low speed in such broad ships had not the models been carefully tried. The results justified the reliance placed upon the model experiments but the ships are too broad. At first the "Ajax" and "Agamemnon" were unsteady on a course, and sheered from it. This was corrected by a simple device suggested by the Admiralty tank experiments. The "Colossus" and "Edinburgh" show a return to increased length in proportion to breadth.

While these ships were building the Controller of the Navy, Sir W. Houston Stewart, did his best to get from the Ordnance Department breech-loading guns. When the opposition to the breech-loading

system eventually gave way the new era was immediately signalised by a change in the mounting from turret to barbette.

Sir Houston Stewart, had for many years desired to mount heavy guns *en barbette*, as the French did, but with muzzle loading guns it was impossible. As soon as the new gun was accepted in principle, Mr. George Rendel was ready with a design for a barbette to work a pair of large guns together. With this barbette tower it was possible to raise the guns much higher than in a turret, without an increase in the weight of the armoured protection.

The central elevated platform of the earlier ships, with the guns *en échelon*, was at once abandoned, and the "Collingwood" arrangement as compared with that of the "Colossus" marks the return of the gunmakers to reason. The barbette arrangement has now completely displaced that of the turret in British ships.

The "Nile" and "Trafalgar" represent the views of those who wished to adhere to the turret, and desired to revert to a large amount of thick side armour. The ships were well designed and built, and there are those who think their conception was wise and timely.

The "Devastation," "Thunderer," "Dreadnought," "Inflexible," "Ajax," "Agamemnon," "Colossus," and "Edinburgh" are all of the monitor type and grew out of the American system. Low side freeboard, thick armour, a few heavy guns and no secondary armament are the notes of the system. Regarded as a part of the naval centre plan much may be said for them, and they may wait for the eventual and certain acceptance of that plan. As parts of a fleet of fast ships engaged in naval tactics, they are obsolete.

With breech-loading guns it became possible to give a secondary armament, which is the first step towards putting everything into one ship and having large crews. In the "Collingwood" this was done. These features are always dear to the naval mind and they have been extended and carefully applied in the splendid fleet produced from the designs of Sir William White between 1886 and 1900.

In the *Naval Review* published by the present writer in 1886 reference was made to a pamphlet printed and circulated by Admiralty order in January, 1878, in the following terms:—

"Of protected ships there are many varieties:—

I. "The ships of the 'Comus' class; i. e., corvettes of 2,300 tons displacement. They have an underwater steel deck wrought over the engines, boilers, and magazines, with a raft body above it. This is, in virtue of its position as against blows of projectiles, as effective a protection for these parts of the ship as would be given by armour on the sides.

II. "The ships of the 'Warrior' type; viz. 'Warrior,' 'Black Prince,' 'Resistance,' and 'Defence.' These ships are divided into three parts longitudinally. There is a middle division, varying between one-half and three-fifths of the whole length of the water-line, which has a belt of armour on the sides and ends; and there are two end divisions protected by an underwater deck, as in the 'Comus,' but without a raft body.* The 'Resistance' and 'Defence' have a protected part for half the length of water-line and the 'Warrior' and 'Black Prince,' which are 380 feet long, have armour for only 213 feet. These ships then have,

* In these early ships the underwater decks are dangerously thin, as is also the side armour.

as above stated, three divisions; viz. side-armoured middles, and protected ends.

III. "There is the ship protected by side armour through the water-line, associated either with a short or with a long and conterminous armoured battery overhead. In the latter case the ship is said to be completely protected, in the former only belted; but in neither of these cases is there a protecting under-water deck. This class includes nearly all the completed iron-clads of all navies, and all the protected ships designed in England between 1861 and 1873.

IV. "There is the ship protected by side armour on a middle division of the ship associated with protected ends and raft bodies. In this division is included the 'Inflexible,' 'Ajax,' 'Agamemnon,' 'Nelson,' and 'Northampton,' the "Duilio,' 'Dandolo,' and the German ships of the 'Sachsen' type.

V. "There is the ship with protecting deck and raft bodies from end to end, without side armour, but with armoured batteries, to which it has been understood that the 'Italia' and 'Lepanto' are to belong, but of which there is no actual representative at present." (1878.)

In my opinion all ships of 3,000 tons displacement and upwards, should be protected. Those intended for high speed and cruising, and not having large batteries, or many men about the decks, might be well protected either as Class I. or as Class II. The great favour which Class III. has received in all navies, and the large number of existing ships of the type will perhaps cause it to keep in favour for second-class battle-ships for a few years more. Class IV. must take all first-class ships for the future, unless Class V. should establish itself, and in that case it is likely to become the permanent type, with general

improvements in the manner of constructing the raft and mounting and protecting the guns. If we are obliged to stop at Class IV. there may be a greater widening and shortening of the ship than there is in the "Inflexible," and both the gun and the armour will grow. If we can happily succeed in passing to Class V. we may have more reasonable proportions in ships, and the increase in thickness of armour and in power of individual guns may be arrested.

Going over the ships produced later it appears that first, all the fighting ships are protected. Next, very few ships with side armour throughout the water-line have been built. Lastly, we have succeeded in passing to Class V. with more reasonable proportions in ships; i. e., they are longer, and the increase in thickness of armour and in the power of individual guns has been arrested. See the development diagrams A and B.

The trend of development is shown clearly also in the relative movement on the different navy lists of 1898 as compared with those of 1896. Looking to completed sea-going ships of 2,000 tons and upwards it appears from Sir Chas. Dilke's Return of May, 1898, that the following changes had occurred since August, 1896:—

FRANCE.

Removed from List.

"Suffren"	Wooden	Armoured Battle-Ship.
"Triomphante"	"	" " "
"Dupetit Thouars"	"	Unprotected Ship.
"Villars"	"	" "
"Forfait"	"	" "
"Roland"	"	" "

Added to the List.

	Tons.	
"Galilee"	2,280	Protected Cruiser.
"Cassard"............	3,890	" "
"D'Assas"............	3,890	" "
"Du Chayla".........	3,890	" "
"Pothuau"...........	5,275	" "
"Pascal".............	3,952	" "
"Descartes"..........	3,927	" "

GERMANY.

Removed from List.

"Freya"............................Unprotected Cruiser.

Added to the List.

	Tons.	
"Ægir"	3,474	Armoured Ship.
"Hela"...............	1,971	Protected Cruiser.

ITALY.

Two armoured ships of 1864 of between 4,000 and 5,000 tons, the "Ancona" and the "Castelfidardo," not appearing on the list 1896, have been re-instated.

Added to the List.

	Tons.	
"Carlo Alberto".......	6,396	Armoured Cruiser.
"Vettor Pisani".......	6,396	" "

RUSSIA.

Added to the List.

	Tons.	
"Petropavlosk"	10,960	Armoured Ship.
"Sissoi Veliki"	8,880	" "
"Three Saints"	12,480	" "
"Rossiya"	12,300	Armoured Cruiser.
"Svietlana"	3,828	Protected "

GREAT BRITAIN.

Added to the List.

	Tons.	
"Illustrious"	14,900	Armoured Ship.
"Cæsar"	14,900	" "
"Hannibal"	14,900	" "
"Mars"	14,900	" "
"Jupiter"	14,900	" "
"Victorious"	14,900	" "
"Prince George"	14,900	" "
"Isis"	5,600	Protected Cruiser.
"Arrogant"	5,750	" "
"Dido"	5,600	" "
"Doris"	5,600	" "
"Diana"	5,600	" "
"Juno"	5,600	" "
"Powerful"	14,200	" "
"Terrible"	14,200	" "

Ships of war are designed to attempt to disable or to sink any other ship which may be opposed to them. Every ship of war is presumed to be incapable of resisting the well directed attacks of an efficient enemy. However strong the ship may be she is exposed to fatal assaults upon her floating power. If she has invulnerable side armour, the torpedo and

the ram threaten her by means of attack upon the plating, $\frac{3}{4}$ in. thick, which is her sole defence from five or six feet beneath the water to the keel. But, confining attention to the gun, the best security for the buoyancy lies in a nearly complete water-line belt or in a raft body. Many naval officers have contended for a complete belt and have supposed the ram to be weak if it is unsupported by the armour belt. It is only necessary to remember the parallel cases of the "König Wilhelm," fatally ramming the "Grosser Kurfürst," and the "Camperdown" fatally ramming the "Victoria." "The Grosser Kurfürst's" side at the under edge of her armour belt was certainly no better able to resist a blow than was the edge of the well stiffened 3-inch steel deck of the "Victoria," yet the blow in the first case twisted the ram of the König Wilhelm" out of its place right down to the keel and turned it round against the bow plating. In the "Camperdown" the ram, which ends under the armoured deck, was uninjured. The stem forging above this deck, which finishes the unarmoured structure; this alone was forced out of place. The water admitted here would not have exceeded fifty tons had there been no scuttles left open during the manœuvres in the shot proof deck itself.

Next to the nearly complete invulnerable water-line belt, as a defence of buoyancy against the gun, must come, as the author believes, the shortened invulnerable water-line belt arranged as in the "Camperdown."

Looking to the many guns which can drive holes through armour we may see that armour thin enough to be smashed does not occupy the next place to invulnerable armour in usefulness. However long it may be, a belt of such thin armour is no defence either of

buoyancy or of the vital parts of the ship. Next in efficiency to a complete invulnerable belt is a shortened invulnerable belt, and next to that the arrangement by which side armour is abandoned and an armoured deck covers all the vital parts of the ship.

As against light guns of the quick-firing type the case is different. Here the more side armour there is, the better, even though it be thin. A broad continuous, or nearly continuous belt would be best against such guns, on the understanding that heavier guns are not to attack it.

A ship, for example, armed almost exclusively with 6-in. Q. F. guns; 12-prs; and 3-prs, and, therefore, likely to be attacked in return by a similar armament, might be expected to have a water-line belt of armour proof to such guns. But there are ships so armed, with from 800 to 900 men in the crew, and the buoyancy has no such protection; there is no side armour.

The difficulties attending the question of the defence of buoyancy and stability against the gun are so serious that there is room for great changes in the future. The author's firm belief is that side armour will be abandoned and that the raft-bodied system will enter upon a new phase.

Iron or steel whether in thin plating or in thick plating is not a material which can be trusted to defend the water-line of the ship against flooding. Its fractures and perforations make it necessarily inferior to a solid or approximately solid deck or raft eight or nine feet thick at the water-line.

The sketches which have been published by Lord Brassey in the last volume of the *Naval Annual* (1901) appear to threaten destruction to unarmoured structures as soon as fire is opened upon them. But

it is to be remembered that the wood in the "Belleisle" did not take fire under tremendous shell attack, although it had not been rendered uninflammable by chemical process. Next, no trial was made by high explosive shell fired into coal. Ordinary shell will not set small coal on fire. The fire of the high explosive is less likely to do so. The best way of meeting these high explosive shells within unarmoured sides has not yet been considered. It has been thought enough to attempt to cover the sides with armour thick enough to explode the shell on the outside of the ship. This is the most serious problem at the present moment, as ships in all navies have large unarmoured spaces which must somehow be protected either by overwhelming fire from behind them or else by defensive arrangements.

Meanwhile it cannot be too often said that naval officers should have practical demonstration of the effect of the admission of water.

1. Through a breach in the armour abreast the engine room or boiler room; (a) the side coal bunker bulkhead remaining effective; (b) not remaining effective.

2. Through injury to the unarmoured ends of ships with short belts; (a) with the ends properly stowed; (b) not properly stowed.

3. Through injury to the side above a low belt; (a) when the between decks wing spaces are properly stowed; (b) not properly stowed.

4. The admission of water in protected ships upon an armoured deck lying below the water-line; (a) the spaces over the deck properly stowed; (b) not properly stowed.

5. The admission of water in protected ships where the armoured deck is arched, so as to be some feet

under water at sides and some feet above water amidships; (a) when the water lies on one side of the deck only and the ship lists; (b) when this list is corrected and the crown of the deck is thereby brought down to the water level. In this case also the difference in the behaviour of the ship when the over deck space is properly stowed, and when it is not, requires to be carefully noted.

The effect in all these cases will be modified by the proportions of the ship. The broad ships will suffer less than the narrow ones.

There would probably be a difference in this respect between the "Camperdown," 330 ft. long and $68\frac{1}{2}$ ft. broad, and the "Kaiser Wilhelm II." 369 ft. long and 65 ft. broad.

This chapter would be incomplete if no reference were made to the remarkable contribution made by the United States of America in 1861, in the development of armed ships. It was not a contribution of any value in shipbuilding or in marine engineering, but it was the most striking illustration of enterprise and resourcefulness which is presented in the whole story of naval development during the century.

The story is told in the words of Mr. F. M. Bennett, engineer U. S. A., in the pages of *Cassier's Magazine*, April, 1898. It is there illustrated by charming sketches and photographs. In these more sober pages the words of the story are vivid enough for the purpose.

Mr. Bennett says:—

"Of John Ericsson it is hardly necessary to speak. The foremost man of his time in his profession, his fame is secure for all time, and the story of his achievements is too well known to need re-telling. His influence upon American history, exerted through

H.M.S. "CAMPERDOWN."

the medium of the 'Monitor' alone, was remarkable and has been fully recognised by historians. As eminent an authority as Dr. John Fiske, in his *History of the United States*, concludes the account of the famous iron-clad duel with this reflection: 'Among the great men who saved the Union and freed the slaves, one of the most important was the man of science, John Ericsson.'

"The use of iron for armouring war vessels was not a novel idea in 1861. The Stevens Battery, intended to be shot and shell-proof by iron armour, was still unfinished, but dated as far back as 1842. Three iron-plated floating batteries had been used by the French in the Crimean war. Both England and France had put light iron plates on large frigates and each country was building a dozen or more similar ships. The 'Warrior,' 'Black Prince,' and 'La Gloire' were types of these vessels, which were full-rigged ships with auxiliary steam power, sail rather than steam being the real motive power. The Secretary of the United States Navy (Mr. Gideon Welles), in reporting the state of the navy to Congress in July, 1861, remarked upon the use of armour in other countries, and asked authority to build armoured vessels should such construction be recommended by a competent board of officers after investigating the subject.

"Congress responded by an act, approved August 3, 1861, authorising the Secretary to appoint a board of three officers to investigate the question, directing him to have built one or more iron or steel-clad steam-ships or steam batteries' should the report of the board be favourable, and appropriating one million, five hundred thousand dollars to execute the work. An advertisement was at once issued by the United States

Navy Department asking bids from responsible persons for the construction of iron-clad steam vessels of war, dimensions and qualities stated in general terms in the advertisement. Descriptions and drawings of all proposals submitted were required, and twenty-five working days from date of advertisement were allowed for the presentation of plans.

"A board composed of two commodores and one commander, all officers of distinction, was appointed to consider and report on the plans. The report of this board is a fair exposition of the naval and scientific beliefs of the time.

"They said, 'For coast and harbour defence they (iron-clad ships) are, undoubtedly, formidable adjuncts to fortifications on land. As cruising vessels, however, we are skeptical as to their advantage and ultimate adoption.

" 'The enormous load of iron, as so much additional weight to the vessel; the great breadth of beam necessary to give her stability; the short supply of coal she will be able to stow in her bunkers; the greater power required to propel her; and the largely increased cost of construction, are objections to this class of vessel as cruisers, which we believe it is difficult to overcome.

" 'From what we know of the comparative advantages and disadvantages of ships constructed of wood over those of iron, we are clearly of opinion that no iron-clad vessel of equal displacement can be made to obtain the same speed as one not thus encumbered, because her form would be better adapted to speed."

" 'As yet we know of nothing superior to the large and heavy spherical shot in its destructive effects on vessels, whether plated or not. It is assumed that 4½-inch plates are the heaviest armour a sea-going vessel can safely carry.'

"This board reported on seventeen propositions for armoured vessels. From these proposals the board selected three and recommended that contracts be made with the bidders as follows:—

"With C. S. Bushnell & Co., of New Haven, Conn., for an iron-clad gun boat on the rail and plate principle, the resulting vessel being the first 'Galena.'

"With Merrick & Sons, of Philadelphia, for a large wooden ship with iron citadel, subsequently named "New Ironsides."

"With John Ericsson for the 'Monitor.'

"It was only by a train of accidental happenings, that the plan of the 'Monitor' ever came before the board and was accepted. When Mr. Bushnell learned that his plan for the 'Galena' would be accepted he went to New York to consult Ericsson about the details of the vessel he expected to build. Ericsson exhibited to him a model showing the principles of the 'Monitor,' the model being a modification of one he had submitted to the Emperor Napoleon III. in 1854.

"The Napoleon model had a shield or 'turtle-back' deck and its turret was in the form of a hemisphere. Mr. Bushnell observed the possibilities of the model and by taking advantage of personal acquaintance laid it before Secretary Welles. Soon thereafter Mr. Bushnell took the model to Washington and exhibited it to the Board, where it excited some interest and was then rejected. Bushnell induced Ericsson to make the journey to Washington and explain his design, which Ericsson did with such eloquence and masterly show of knowledge that his plan was accepted and he was told to proceed at once with the construction. With the energy for which he was famous, Ericsson had material for his vessel going

through the rolling mills in the few days that elapsed before the formal contract was prepared.

"The contract, dated October 4, 1861, required Ericsson and his sureties to build an iron-clad, shot-proof steam battery, of iron and wood combined, of dimensions stated in general terms in the contract. A sea speed of eight knots per hour, to be maintained for twelve consecutive hours, was stipulated. The contract price was 275,000 dollars, to be paid in five instalments of 50,000 dollars each, and one of 25,000 dollars, payments to be made as often as the superintendent of construction should report that the progress of work warranted. A reservation of 25 per cent was withheld from each payment, to be retained until after the satisfactory trial of the vessel, not later than ninety days after she should be ready for sea. The superintendent of construction of the entire vessel was Chief Engineer Alban C. Stimers, United States Navy.

"One clause of the contract provided that if the vessel failed to make the specified speed, or should be wanting in other respects, the contractors should refund the full amount that had been paid them. This provision is the basis of the widespread fiction that Ericsson and his sureties paid for the building of the 'Monitor' out of their own pockets, and were reimbursed only after she had proved her worth in battle. Fact is, that every payment was made according to contract before the vessel left New York and the 25 per cent reservation was paid within a week after the famous duel in Hampton Roads. Her performance on that occasion was considered satisfactory, though her speed was not up to contract requirements.

"Another requirement of the contract shows how reluctant the naval experts of that day were to admit

steam on board ship on any terms except as an adjunct. It required the contractor to 'furnish masts, spars, sails, and rigging of sufficient dimensions to drive the vessel at the rate of six knots per hour in a fair breeze of wind.' Ericsson's idea of stability as applied to light-draft vessels did not agree with this requirement, and he did not observe it; nor does it appear that the naval officials attempted to enforce it. At any rate, the Monitor was a steamer pure and simple, without mast, spar, or sail. Not many years later the top hamper of masts and sails on a low freeboard turret-ship gave the British navy the tragedy of the 'Captain.'

"The name 'Monitor' was given by Ericsson himself, as shown by the following letter written by him in January, 1862, to Assistant Secretary of the Navy, G. V. Fox:—

" 'Sir—In accordance with your request, I now submit for your approbation a name for the floating battery at Greenpoint. The impregnable and aggressive character of this structure will admonish the leaders of the Southern Rebellion that the batteries on the banks of their rivers will no longer present barriers to the entrance of the Union forces. The iron-clad intruder will thus prove a severe monitor to those leaders. But there are other leaders who will also be startled and admonished by the booming of the guns of the impregnable iron turret. 'Downing Street' will hardly view with indifference this last 'Yankee notion,' this monitor. To the Lords of the Admiralty the new craft will be a monitor, suggesting doubts as to the propriety of completing those four steel-clad ships at three and a half million a piece. On these and many other similar grounds, I propose to name the new battery 'Monitor.' "

"Every detail of this epoch-making craft sprung from the vigorous brain of John Ericsson, and his restless energy rushed the work forward with unprecedented rapidity. Hull, machinery, turret, gun-mounts, all that was in her, in short, grew from his designs. Working drawings, often rude and only in pencil, went from his table to his aides to be perfected, or directly to the workshops, almost as fast as sheets from a printing press.

"To hasten the work to the utmost, it was parcelled out to many contractors. The hull was built by Thomas F. Rowland at the Continental Iron Works, at Greenpoint, N. Y.; the main engines and auxiliary machinery were built by Delamater & Co., of New York; and the turret came from the Novelty Iron Works, also of New York. The turret was built up of eight layers of one-inch iron plates, bolted together. Many lesser establishments contributed to the work by subcontracts for bolts, rivets, and other material. Ericsson hoped for 15-inch guns, but they could not be made in time. The ship was launched on January 30, 1862, with her main engines installed on board; this was 101 working days from the date of contract.

"The dimensions of the vessel as built followed closely the figures named in the contract. The extreme length was 172 feet; extreme beam, 41 feet 6 inches. The iron hull was 124 feet long, 18 feet wide at the bottom, and 34 feet wide at its junction with the armour raft, or upper body; depth of hold 11 feet 4 inches; mean draft, 10 feet 6 inches; inside diameter of turret, 20 feet; height of turret, 9 feet; displacement 987 tons. The deck was covered with iron plates one inch thick, and the sides of the upper body had five inches of iron armour.

"The upper body was a sort of wooden raft on top

of the iron hull. It is difficult to describe this arrangement to any one not familiar with ship construction. An elongated shallow tin pan with a heavy, iron-bound plank of the same shape, but considerably longer and somewhat wider, laid on top of it and set afloat may give the general idea. Ericsson himself described the invention as a fort on a raft. It was not pretty, nor 'ship-shape,' according to the notions then prevalent; but it was the germ of the modern battle-ship.

"The top of the turret was made of bars of commercial railway iron, two small openings being left for escape hatches. The turret was large enough to permit of loading the gun at the muzzle when it was run in. During this operation the gun ports were screened by huge iron pendulums, hanging from the top of the turret, suitable eye bolts and tackles being provided for heaving these pendulums aside when the guns were to be run out. The pilot house, built log-cabin fashion, of heavy iron billets, 9x12 inches, with the corners dovetailed and bolted, was far forward on deck, with no communication with the turret, except a speaking tube. This voice pipe was found unreliable, and the position of the pilot house prevented ahead firing. In all monitors built afterwards, the pilot house was put on top of the turret.

"Ericsson's favourite steam engine was that described as the vibrating lever type, by which a rocking or oscillating motion was changed to rotation by means of connecting rods. His first application of this was the rather remarkable half-cylinder engine with swinging 'barn-door' piston, put in the 'Princeton' in 1843. Double-trunk cylinders followed this, and the final development appeared in the great 100-inch engines of the 'Dictator' and 'Madawaska,' of the

United States navy, in which the steam cylinders were not different from other practice, but still transmitted power by the rocking arms.

"There were two return tube 'box' boilers, placed side by side, forward of the engines, each containing two furnaces, joined to the back combustion chambers by large oval flues. The height of the boilers from water-bottoms to top of shell was nine feet, from which it will be seen that they occupied practically all the vertical space between the deck and bottom of the ship. Each boiler discharged its smoke through a short uptake to a grated hole flush with the deck, there being no smoke-pipe. The object of this was to avoid an obstacle to firing the guns. In all subsequent monitors smoke-pipes were provided.

"Without air downtakes or ventilators, a mild forced-draft system had to be resorted to. This was supplied by two steam engines driving, by belting, two large blowers which discharged air into the engine and fire-rooms, whence it had no egress except through the furnaces. Air for the blowers was drawn from grated openings in the deck similar to those provided for the escape of smoke. The object of the gratings, of course, was to prevent missiles and débris falling into the blowers or boiler uptakes. Low iron coamings, or trunks, about five feet high, were provided to exclude water from these deck openings in a seaway. When cleared for action these trunks were to be unshipped, leaving the deck entirely clear, except for the pilot house.

"The anchor, instead of being catted and fished to the usual position on the edge of the upper deck forward, was arranged to be hove in by its own chain to a recess in the forward overhang. From there it could be worked by simply heaving in or veering

chain, without endangering men on the low deck in rough weather or in the presence of the enemy. In this position also it was out of the way and was safe from being carried away by shot. Ericsson regarded this protection of the anchor as an important feature, and later greatly resented adverse criticism of naval captains regarding it.

"On February 19, three weeks after launching, the 'Monitor' had a trial trip that was such a failure that she had to be towed home. Almost everything went wrong. This is not to be wondered at, however, when we remember how rapidly the structure had been assembled and that it was composed of many pieces from many workshops, made from rough plans. The trouble with the propelling engines was charged to faulty valve-setting and was easily remedied. Both gun mounts were disabled because the guns were fired without compressing the friction gear by which the recoil was to be taken up,but the damage was small considering the possibility for a general smash-up.

"The greatest defect was the lack of control of the vessel by the steering gear.

"The first trial trip developed many faults that were to be expected in such a hastily-built craft. These were remedied within two weeks, and on March 4, a final, and successful trial trip was run, the guns were satisfactorily tried, and a favourable report was made by a board of naval officers. Two days later she went to sea under convoy and in tow, though using her own steam as well. She had been formally commissioned on February 25 under command of Lieutenant John L. Worden, United States Navy. Twelve officers and forty-five enlisted men comprised her personnel. Chief Engineer A. C. Stimers, the superintendent of construction, went to sea in the

vessel to observe her performance and give the officers the benefit of his knowledge. He was, as stated by Colonel W. C. Church, in his *Life of John Ericsson*, 'the only man on board who thoroughly understood the characteristics of the vessel.'

"The voyage to Hampton Roads was eventful and almost ended the career of the 'Monitor,' and with it the fate of iron-clads for an indefinite time. Rough weather was encountered, and water broke over the smoke and blower trunks, nearly putting out the fires and stopping the pumps from lack of steam for four or five hours on one occasion. Loss by foundering was imminent at this time because of the great quantity of water that got into the vessel under the base of the turret and through the hawse pipes. The blowers stopped because the belts got wet and the engine and fire-rooms filled with noxious gas from the fires and had to be abandoned. In trying to remedy this trouble, the chief engineer, Mr. Newton, and his assistants were overcome by the gas and were carried to the top of the turret where they revived, though they were thought dead when dragged out of the engine-room. Trouble and danger also resulted from the wheel-ropes jumping off the steering wheel and becoming jammed.

"After two days of toil and peril the 'Monitor' escaped from the dangers of the sea into the presence of a new enemy. Late in the afternoon of March 8 she passed in at the Capes of Chespeake, and from the sound of shotted guns knew that her time for action had come thus early in her career. The 'Merrimac' was abroad that very afternoon, and wreck and destruction followed her wake. A rude improvised iron-clad herself, she marked a new era in naval warfare, and before her a large fleet of supposedly

formidable ships of war was as helpless as a flock of sheep assailed by a wolf.

"Night fell before the 'Monitor' came up to the seemingly doomed Union fleet in Hampton Roads. The 'Merrimac' had glutted her thirst for blood for the day and was at anchor and at rest, but in her silence in presence of the ships that she meant to attack in the morning she stood for all that men understand by the dominion of the seas. Lighted by the burning wreck of the frigate 'Congress,' the "Monitor' moved up toward Newport News and anchored near the stranded 'Minnesota,' upon which vessel, it was certain, the first blow of the morrow would fall.

"The 'Merrimac' got under way on Sunday morning, March 9, with the intention of destroying the Union fleet lying at her mercy. When she advanced to attack the "Minnesota," the "Monitor" came out from behind the big frigate and assumed the rôle of defender. In the furious duel between the iron-clads that followed, neither was vanquished. The 'Merrimac' retired to Norfolk without having accomplished any part of her projected day's work, and the 'Monitor' remained on guard, successful in the duty she had undertaken, and ready to fight the first comer.

"In the fight the 'Monitor' fired forty-one solid 11-inch round shot, twenty of which made marks that were afterward observed on the shield of the 'Merrimac;' the iron plating of the latter was much disturbed and broken, but the casemate was nowhere pierced all through. Twenty-one of the 'Merrimac's' shells (she fired no solid shot), struck the 'Monitor,' the most damaging blow being one that cracked an iron 'log' of the pilot house and disabled Lieutenant Worden. Two men in the turret were disabled by concussion. No one was killed on the 'Monitor.'

"As the first conflict between mastless steamers,—engineer's ships,—it will be interesting to remark briefly the part taken by men of the engineering force. The crew of the 'Monitor,' including Chief Engineer Stimers, numbered fifty-eight. Of these, thirteen were officers. Five officers were of the line, or seaman branch; five were engineers; the others were the surgeon, paymaster, and captain's clerk. Twenty-one enlisted men were petty officers, seamen, and landsmen of the seaman class; seventeen were firemen and others belonging to the engineer class. The remaining seven were yeomen, stewards and cooks. It appears that the fighting force,—the men at the guns, in the magazine, and at the engines and boilers supplying power to handle the ship and the guns, were almost equally divided between the seamen and engineering branches.

"The 'Monitor' was doomed to a short existence. After the fight she remained at Hampton Roads in anticipation of another raid by the 'Merrimac,' engaging once the batteries on Sewall's Point. On May 12 she led the squadron of vessels that went to Norfolk on the evacuation of that place by the enemy. Three days later, with the 'Galena' and three other vessels, she went up the James river to within seven miles of Richmond and attacked Fort Darling, on Drury's Bluff. Owing to difficulty in elevating her guns enough to bear on the fort, her part in the attack was insignificant: she was struck three times and had no casualties. The 'Galena,' another product of the armour-clad board, it will be remembered, was roughly used by the plunging shot from the bluff. Her Captain, the gallant John Rogers, remarked in his report: 'We demonstrated that she is not shot proof.' Her

bar armour was shot through thirteen times; thirteen of her men were killed and eleven were wounded.

"During the summer months the 'Monitor' remained in the James River on patrol duty, often engaged with the enemy's sharpshooters and shore batteries. At the end of the year the Navy Department began assembling a fleet of iron-clads off Charleston for the reduction of that place. The 'Monitor' and a new and improved monitor—the 'Passaic'—left Hampton Roads on December 29, under tow, but using their own engines. The next night, off Cape Hatteras, heavy weather was encountered and the 'Monitor' foundered. Water in quantities came in under the turret and through the hawse pipes, and the experiences of her first sea trip were generally renewed.

"The water gained steadily and impaired the fires by swashing against the grate bars, until the falling steam pressure showed too plainly that the engines and pumps must soon stop. At 10:30 p. m. signals of distress were made to the vessel towing her—the Rhode Island—and that vessel undertook the dangerous and very difficult task of removing the crew by means of boats in the heavy sea, but before the work was done the 'Monitor' sank. This happened soon after midnight in the morning of December 31, 1862, about twenty miles south-south-west of Cape Hatteras. In Commander Bankhead's report of the disaster he asserted his conviction that a serious leak had been sprung by the pounding of the sea, separating the iron hull from the upper body, and this seems very probable." So runs Mr. Bennett's story in *Cassier*.

There can be no doubt that the report of the captain as to the cause of the leak was well founded. The blows of the sea under the overhanging armoured

sides, the flat shelves of which were five feet under water, must have been in themselves more than the ship could bear. In addition to this the flat bottom of the vessel was only 10½ feet under water and in a heavy seaway waves would strike her under this flat surface. She was too large and heavy to rise to them and the force of their blows would be too much for any ship to endure. A far larger and stronger ship, built many years afterwards, the "Livadia," Russian Imperial Yacht, suffered so severely from this cause owing to her shallow draught and flatness of bottom that she was found to be unable to live in such a sea as that which brought the "Monitor" to an untimely end.

The introduction of the armoured turret in the "Monitor" influenced all the future of armed ships and in the form of turret or barbette the revolving gun behind armour survives in all navies.

The sea-going qualities of ships with such a low freeboard came as a surprise to the ship-builders. Ship-building practice was for a time influenced by a consideration of the advantages offered by low freeboard in fighting ships, but these considerations have been overborne in recent ships for the purpose of securing dry upper decks from end to end in a sea-way, another ominous sign perhaps of desire for easy living in a ship of war.

CHAPTER VI.

PROPELLING MACHINERY.

The enormous changes which have been or still have to be considered in the dimensions, materials of construction, and speeds of ships have been brought about by the Marine Engineer. The Naval Architect specifies the power which the engines are required to develop, but he has previously been intently watching the progress of the Engineer in raising steam pressures, increasing the number of revolutions of engines, and gaining in the amount of steam he can produce per square foot of grate surface, and per pound of coal.

He takes advantage of the Engineer's achievements and sets his demands a little in advance of what has already been done. Step by step, it has been the advance of the Engineers which has been the cause of the success of the new ventures of the Naval Architect.

The ship-builder sometimes modifies form and proportions in the ships and gains in doing so, but all these modifications follow the marine engine in its development of power in proportion to its own weight, and to the weight of fuel it requires. And even in the forms and proportions of ships it is the Marine Engineer who strikes out new roads, as we have seen in the development of the torpedo boats and vessels.

When the Institution of Naval Architects was

founded in 1860 ship-builders had already seen Mr. Brunel doing the work of an expert of the first rank in their own profession, and they knew that in the State service in France no such division between ship-building and Marine engineering existed as that with which they were familiar. Yet the Membership of the Institution was confined to naval architects and ship-builders; and marine engineers were only associates. In the course of a few years the distinction vanished and the bulk of the present members have been trained as marine engineers.

In the future the ship-builders who are not marine engineers must still further diminish. The profession of shipwright outside the government dockyards cannot now produce naval architects or ship-builders in England. Within the government yards all the apprentices are trained as fitters, familiar with machinery, and these may find their way, if they leave the dockyards, into the ranks of the marine engineers.

The Royal Corps of Naval Constructors, founded by the joint influence of Lord Brassey and Sir Houston Stewart will so long as it exists be a security for the possession by the state of a competent Designing Staff.

The Marine Steam Engine is already such a fearsome thing to care for, and drive, that men shrink from making changes in engines of large and settled type; and had it not been for the possibility of experimenting in torpedo boat machinery the advances made in the larger types would have been impossible. Higher steam pressures, faster engines, forced draft, water tube boilers, and well formed propellers; all these subjects have been submitted to repeated and crucial trials in torpedo vessels, and have then found their way into the larger ships. The men to whom

this is due are Mr. Thornycroft, Mr. Yarrow, and M. Normand.

The first step was the building of the "Miranda" at Chiswick. A marine engineer writing to the *Times* concerning the review of the fleet in 1897 generously acknowledges this. He says:—

"In the earliest days of steam navigation, when the Queen came to the throne, three lbs. steam pressure per square inch was the ruling practice, and about half a ton of machinery was required to produce one indicated horse-power. At the expiration of about thirty years—i. e., in the year 1867—pressures had risen to 20 lbs. or even 30 lbs. to the square inch, and piston speeds had progressed from the original 220 ft. per minute to as high as 450 ft. or 500 ft. per minute. At first as much as five lbs. to seven lbs. of coal were often burnt to produce one-horse power for an hour, but by the time Her Majesty had half completed the period during which she has reigned, the consumption of coal had been reduced to from 3½ lbs. to 2½ lbs. for the same purpose. Up to that time the ordinary marine boiler was rectangular in form, and was appropriately known as the 'box-boiler.' When the 'Devastation' came out in 1873 not much advance had been made. She had the same type of direct-acting horizontal trunk engines of the simple or non-compound type, and her boilers, which were of the rectangular type, were only pressed to 30 lbs. to the square inch. The weight of all machinery complete was 2.96 cwts. per indicated horse-power. Her piston speed on trial was a little over 500 ft. per minute. In the 'Inflexible,' which was anchored close to the 'Devastation' on Saturday, we have another vessel representing an advance in warship machinery. She was completed in 1881 and had cylindrical boilers pressed

to 60 lbs. to the square inch, and had compound engines made by John Elder and Co., the firm that first introduced this type of engine into marine practice. Her piston speed was close on 600 ft. per minute on trial.

"Without dwelling upon other typical vessels present at the review we will give corresponding details of one of the most recent vessels present. The 'Royal Sovereign' which was second in the line containing the chief battle-ships, represents a class of vessels having triple-expansion engines and cylindrical return-tube boilers. The pressure of steam is 155 lbs. per square inch and the piston speed is over 900 ft. per minute. About 1¾ cwts. of machinery were required to give one indicated horse power. The coal burnt to produce one indicated horse power for an hour was at full speed about 2 lbs., although better economy could be obtained at lower speeds.

"It will thus be seen that during Her Majesty's reign, steam pressures have risen from 3 lbs. to 155 lbs. (we exclude the water-tube boiler, to which reference will be made presently), piston speeds have advanced from 220 ft. to not far from 1,000 ft. per minute, and as a consequence—for steam pressure and piston speed are the chief elements contributing to lightness—the weight of marine machinery of large ships has fallen from 10 cwts. per indicated horse-power to 1¾ cwts. Coal consumption has kept pace with other features, the economy of modern warship machinery being as notable as its lightness. The fuel burnt has decreased from between 5 lb. and 7 lb. down to 2 lb. per indicated horse-power per hour. These figures do not represent the best that has been done in regard to modern ships, but they may be

taken as fair on the basis of comparison here adopted.

"From an engineer's point of view the line of little vessels that formed the extreme northern line of the fleet was certainly as interesting as any part of the display. In the torpedo boats we have seen in past times the finger-posts to the engineering practice of battle-ships and cruisers that were to come. Higher steam pressures, higher piston speeds, open column engines, and lastly, water-tube boilers have all been led up to by the example of these small and comparatively inexpensive vessels. Probably no engineer has more influenced the course of marine engineering practice than the inventor of the torpedo boat."

The first official report of the trial of a Screw Steamer ever made to the British Admiralty was made by Captain Chappell and Mr. Thomas Lloyd on the 2nd May, 1840.

The vessel reported on was the "Archimedes," built by the Screw Propeller Co., to test the new instrument of propulsion. She was tried against the "Widgeon," which was then the fastest of the Dover Packets. The "Archimedes," assisted by her sail in a fresh breeze, performed the voyage between Dover and Calais in less time than it had ever been performed by H. M. Mail Packets, viz. in two hours one minute from Dover to Calais, and one hour fifty-three and a half minutes from Calais to Dover. The highest speed on these passages was thus 10 knots an hour. Cog wheel gearing was employed to give the necessary velocity to the propeller shaft, and this made so much noise that the Report said the noise alone would prevent it from being supplied to any of H. M. Packets.

It is, however, says the Report, in propelling vessels

of war that the value of Mr. Smith's invention will probably be experienced. In such cases the rumbling noise in the ship made by the spur wheels is of no great moment, even if it cannot be overcome; for outside the vessels the noise is not audible to so great a distance as that made by the common paddle wheel.

Soon afterwards Mr. Brunel was engaged to superintend the fitting of a screw propeller into a ship of war.

The "Rattler," a vessel 176½ feet long, which had been commenced as a paddle wheel steamer was launched at Sheerness and delivered to Messrs. Maudslay and Mr. F. P. Smith to fit screw engines for the trial of various forms of screws. Experiments were commenced on October 30, 1843. The performances of the ship were found to be so satisfactory and the position of the machinery, below the water-line, offered such advantages to a war-ship that in 1845 the Lords of the Admiralty ordered more than twenty vessels to be fitted with screws.

Prior to this date, Mr. Brunel had been mainly instrumental in introducing the screw propeller into the mercantile marine. It had been adopted, on his advice, in the design of the "Great Britain" steamship in 1840. When, in 1845, the screw propeller was adopted for the British Navy it was required that the propeller should be capable of being easily unshipped in any weather at sea so that the ships might retain their sailing power.

In 1850 the screw propelled vessels in the British Navy were as follows:

	Displacement—Tons.	Ind. H. P.	Speed in knots per hour.
"Ajax"	3,090	846	7.1
"Amphion"	2,025	592	6.7
"Archer"	1,238	345	7.8
"Arrogant"	2,444	623	8.3
"Blenheim"	2,790	938	5.8
"Brisk"	1,410	504	7.3
"Conflict"	1,443	777	9.3
"Dauntless"	2,350	1,347	10.0
"Desperate"	1,405	700	9.4
"Encounter"	1,290	646	9.4
"Fairy"	196	321	11.9
"Greenock"	1,835	719	9.6
"Highflyer"	1,775	702	9.4
"Hogue"	3,155	857	5.5
"Horatio"	1,175	553	8.8
"Megæra"	1,554	926	10.2
"Minx"	203	234	9.1
"Miranda"	1,350	613	10.7
"Niger"	1,454	628	8.7
"Phœnix"	1,225	382	7.1
"Plumper"	652	150	6.5
"Rattler"	1,078	437	9.6
"Reynard"	604	153	7.3
"Rifleman"	565	190	8.0
"Sans Pareil"	3,000	622	7.0
"Sharpshooter"	518	365	9.1
"Simoon"	2,240	530	6.7
"Teazer"	205	128	7.7
"Termagant"	2,403	1,350	9.5
"Vulcan"	2,076	793	9.6
"Wasp"	1,086	186	6.0

At that date (1850) there were fast paddle Mail Steamers, but their highest speed did not exceed 13½ knots per hour.

The displacement of ships, indicated power of engines, speeds, and indicated horse-power per ton weight of propelling machinery given below mark the advances made at successive stages.

8

Date.	Ship.	Displacement. Tons.	I. H. P.	Speed. Knots.	I. H. P. per ton weight of machinery (water in boilers).
1859	"Warrior"….	9,210	5,270	14.	6.1
1863	"Bellerophon".	7,550	6,520	14.17	6.6
1878	"Inflexible"…	11,880	8,010	13.81	5.6
1881	"Imperieuse"..	8,400	10,000	16.7	8.
1882	"Mersey"……	4,050	5,000	17.3	12.0
1883	"Collingwood"	9,500	9,500	16.5	7.7
1885	"Howe"…….	10,300	11,500	16.8	11.8
1885	"Galatea"…..	5,000	8,500	18.1	11.7
1886	"Trafalgar"…	11,940	12,000	16.7	12.6
1886	"Melpomene".	2,950	9,000	19.0	14.8
1888	"Blenheim"…	9,000	21,400	21.5	13.8
1889	"Latona"……	3,400	9,000	20.0	13.0
1885	"Sharpshooter"	735	(1) 3,500	20.0	17.0
1891	"Speedy"…..	810	(2) 4,700	20.2	22.1

(1) Belleville boilers put in after 1885.
(2) Thornycroft boilers.

Mr. Thornycroft has given some interesting particulars showing the increases in boiler pressures and in piston speeds at various dates.

		Boiler pressure in lbs.	Revol. per min.	Speed of Piston (ft. per min.)	I. H. P. per ton weight of machinery including boilers and water.
1855	"City of Boston" and "City of New York"	35	20	480	3.7
1857	"Persia"......	25	15	360	4.5
1861	"Holyhead Mails"	25	22	286	7.
1872	"Miranda" (Yacht)	120	600	800	35.6
1876	"Gitana"... ..	120	320	850	51.5
1877	"Lightning"...	120	440	880	39.
1880	Torpedo boats..	130	650	866	33.

The types of machinery in the recent ships of the British Royal Navy are given by the Engineers in-Chief as follows:

The "Anson," "Benbow," "Camperdown," "Collingwood," "Howe" and "Rodney" have vertical, three-cylinder compound engines with twin screws, running about 100 revolutions per minute at full power. The stroke is three feet nine inches and piston speed 750 feet per minute. The "Collingwood" differs slightly from the others, having 95 revolutions per minute; three feet six inch stroke, and a piston speed of 665 feet per minute. The boilers are of the single-ended return-tube type, twelve in number, with three furnaces in each. The load on the safety valves is 90 lbs. per square inch. The boilers are placed in four compartments arranged back to back against a middle line bulkhead.

The "Anson" differs slightly. She has eight four-furnace boilers carrying 100 lbs. of steam.

The "Nile" and "Trafalgar" have vertical three-cylinder, triple-expansion engines, with twin screws running at 95 revolutions per minute at full power. The stroke is four feet three inches; and piston speed 807 feet per minute. They are fitted with six single-ended return-tube boilers. Boiler pressure 135 lbs. per square inch.

The "Hood," "Empress of India," "Repulse," "Royal Sovereign," "Ramillies," "Resolution," "Revenge," and "Royal Oak," have vertical three-cylinder triple-expansion twin-screw engines, designed to run at 108 revolutions per minute at full power of 13,000 I. H. P. The stroke is four feet three inches, and the piston speed 918 feet per minute. The valve gear and propellers (except in "Royal Sovereign") are arranged to work at a maximum power of 11,000 I. H. P. in order to obtain more economical results at ordinary rates of working.

The boilers are of the single-ended return-tube type, eight in number, in four compartments arranged back to back against a middle line division. Each boiler has four furnaces with two, three, or four combustion chambers. The load on the safety valves is 155 lbs. per square inch.

The "Barfleur" and "Centurion" have engines generally similar to the above. The number of revolutions for 13,000 I. H. P. is 105 per minute; the stroke four feet; and the piston speed 840 feet per minute. The boilers are similar to those above, with four furnaces, having two combustion chambers in each. The load on the safety valves is 155 lbs. per square inch.

The "Australia," "Orlando," "Undaunted," "Narcissus," "Galatea," "Immortalité," and "Aurora" have horizontal twin-screw triple-expansion engines running 110 and 115 revolutions per minute at full

power. The stroke is three feet six inches or three feet eight inches and the piston speed 770 or 806 feet per minute. They are fitted with four double-ended boilers, having three furnaces at each end, with either one or three combustion chambers. The steam pressure is 130 lbs. per square inch, except the "Aurora" and "Galatea," which have 135 lbs. and the "Australia," which has 137 lbs.

The "Edgar," "Hawke," Endymion," "Gibraltar," "St. George," "Royal Arthur," "Crescent," "Grafton," "Theseus," have vertical three-cylinder triple-expansion engines, and twin screws designed to work at 100 revolutions per minute at full power. The stroke is four feet three inches and the piston speed 850 feet per minute. The valve gear and propellers, except in the "Edgar," "Hawke" and "Grafton," are arranged to work at a maximum power of 10,000 horses in order to obtain more economical results at ordinary rates of working.

The first five of these vessels have four double-ended and one single-ended boiler: the rest have single-ended four furnace boilers with return tubes. The steam pressure is 155 lbs. per square inch.

The "Mersey," "Severn," "Thames," and "Forth" have horizontal twin-screw, compound, two-cylinder engines, running about 120 revolutions per minute at full power. The stroke is three feet three inches; and the piston speed 780 feet per minute. They are fitted with six boilers of the circular direct-tube type, placed in two compartments. The boiler steam pressure is 110 lbs. per square inch.

The arrangements in 29 ships named below are that there are vertical three-cylinder triple-expansion engines, and twin screws designed to work at 140 revolutions per minute at full power of 9,000 horses.

The stroke is three feet three inches, and the piston speed 910 feet per minute. In the first 21 of these ships there are three double-ended and two single-ended boilers, and in the rest eight single-ended boilers, of the return-tube cylindrical three-furnace type, with separate combustion chambers. They are arranged in two compartments, with stokeholds athwartships. The load on the safety valves is 155 ℔s. per square inch.

The ships are "Andromache," "Apollo," "Indefatigable," "Intrepid," "Iphigenia," "Latona," "Melampus," "Naiad," "Pique," "Rainbow," "Retribution," "Sappho," "Scylla," "Sirius," "Spartan," "Sybille," "Terpsichore," "Thetis," "Tribune," "Æolus," "Brilliant," "Bonaventure," "Cambrian," "Charybdis," "Flora," "Astræa," "Fox," "Forte," "Hermione."

The "Medea" and "Medusa" have vertical twin-screw triple-expansion engines, running at 140 revolutions per minute at full power. The stroke is three feet three inches, the piston speed 910 feet per minute. There are four double-ended boilers; six furnaces with common combustion chambers and the boiler pressure is 155 ℔s. per square inch.

The "Marathon," "Magicienne" and "Melpomene" have horizontal twin-screw, triple-expansion engines, running at 140 revolutions per minute at full speed. The stroke is three feet, the piston speed 840 feet per minute. These are four double-ended, six-furnace boilers, with three combustion chambers in each boiler. The boiler pressure is 155 ℔s. per square inch.

The "Katoomba," "Mildura," "Wallaroo," "Tauranga," and "Ringarooma" have vertical twin-screw, triple-expansion engines running at 160 revolutions

per minute at full power. The stroke is two feet nine inches, and the piston speed 880 feet per minute. They are fitted with four two-furnace, double-ended boilers, having common combustion chambers. The boiler pressure is 155 ℔s. per square inch.

The "Barham" and "Bellona" have vertical twin-screw, triple-expansion engines designed to run at 220 revolutions per minute at full power. The stroke is two feet three inches and the piston speed 990 feet per minute. They are fitted with six locomotive boilers, with wet bottomed fire-boxes. The boiler pressure is 155 ℔s. per square inch.

The "Pallas," "Pearl," "Philomel" and "Phœbe" have vertical three-cylinder, triple-expansion engines, with twin screws designed to run at 100 revolutions per minute at full speed. The stroke is two feet nine inches and the piston speed 880 feet per minute. They are fitted with four double-ended cylindrical return-tube boilers with two furnaces at each end and a separate combustion chamber to each furnace. The boiler pressure is 155 ℔s. per square inch.

The torpedo gunboats have vertical twin-screws, triple-expansion engines. The revolutions per minute at full power vary between 250 and 310; and the piston speed between 875 and 930 feet per minute. The boiler pressure varies between 145 and 155 ℔s. per square inch.

All of them have locomotive boilers, with wet-bottomed fire-boxes, except the "Sharpshooter" which has Belleville boilers, and the "Speedy" which has the Thornycroft water-tube boilers.

These vessels are "Rattlesnake," "Grasshopper," "Sandfly," "Spider," "Sharpshooter," "Spanker," "Boomerang," "Karakatta," "Salamander," "Sea-gull," "Sheldrake," "Assaye," "Plassy," "Skipjack,"

"Speedwell," "Alarm," "Circe," "Gleaner," "Gossamer," "Hebe," "Leda," "Antelope," "Jaseur," "Jason," "Niger," "Onyx," "Renard," "Dryad," "Halcyon," "Harrier," "Hazard," "Hussar" and "Speedy."

Particulars as to the machinery in the ships of the American Navy are given in the tables attached to the chapter entitled *Fifteen Years of Progress in the United States Navy.*

Interesting particulars have been collected by Mr. Maginnis in his work, entitled *The Atlantic Ferry*, giving the type of machinery in the Atlantic Liners.

Some of the more remarkable of these are as follows:—

Ship's Name.	Displacement.	Indicated power.	Type of Engine.	Propellers.	Number and diameter (ins.) of cylinders.	Length of stroke.	Steam pressure.	Number of Furnaces.
	Tons.					ft. in.	lbs.	
"Aller"	10,460	8,200	3 crank triple.	Single.	1 of 44 1 of 70 1 of 108	6.0	150	36
"City of Paris".......	17,270	18,500	do	Twin.	2 of 45 2 of 71 2 of 113	5.0	150	54
"Teutonic"	16,740	17,500	do	Twin.	2 of 43 2 of 68 2 of 110	5.0	180	76
"Fürst Bismarck"....	15,200	17,000	do	Twin.	2 of $43\frac{1}{4}$ 2 of 67 2 of $106\frac{1}{4}$	5.3	160	72
"La Touraine".......	14,920	16,000	do	Twin.	2 of 41 2 of $60\frac{1}{2}$ 2 of 100	$5.5\frac{2}{3}$	160	45
"Campania"	21,000	30,000	Tandem triple 3 crank.	Twin.	4 of 37 2 of 79 4 of 98	5.9	165	100

Ship's Name.	Displacement. Tons.	Indicated power.	Type of Engine.	Propellers.	Number and diameter (ins.) of cylinders.	Length of stroke. ft. in.	Steam pressure. lbs.	Number of Furnaces.
"St. Louis"	16,000	20,500	4 crank quadruple.	Twin.	4 of $28\frac{1}{2}$ 2 of 55 2 of 77 4 of 77	5.0	200	64
"Kaiser Wilhelm der Grosse"	23,760	32,000	4 crank triple..	Twin.	2 of 52 2 of $89\frac{3}{4}$ 4 of $96\frac{1}{2}$	5.9	178	104
"Kaiser Friedrich"...	20,100	27,000	3 crank quadruple.	Twin.	2 of $43\frac{1}{4}$ 2 of $64\frac{1}{4}$ 2 of $92\frac{1}{8}$ 4 of $93\frac{1}{4}$	5.9	225	72
"Oceanic"	26,100	29,000	4 crank triple..	Twin.	2 of $47\frac{1}{2}$ 2 of 79 4 of 93	6.0	192	96
"Deutschland"	24,400	36,000	Tandem quad. 4 crank.	Twin.	4 of $36\frac{5}{8}$ 2 of $73\frac{1}{2}$ 2 of 104 4 of $106\frac{3}{8}$	$6.0\frac{3}{4}$	225	112

In other chapters particulars have been given of the Parsons' Turbine Engine. It seems to have before it a great future.

It is perhaps in relation to the ships which may be designed to serve the double purpose of mercantile service and service in war that it is most interesting. Should it be successful it can be kept below the water-line and below a deck which is itself below the water-line. We may soon see Canada possessing first-class Liners so designed that they may be on the State List of efficient war cruisers and earning the subsidy which will be gladly paid because it will lighten the burden of providing special war cruisers, and will at the same time enlist the services of all designers and marine engineers in strengthening the navy in this branch of war service.

CHAPTER VII.

BOILERS.

Up to the early eighties the most economical boiler for steam pressures of 30 to 40 lbs. per square inch above the atmosphere was one with flat bottom, top, sides and ends. The strains were principally resisted by numerous internal straight iron stay rods. As the demand arose for higher steam pressures the unsuitability of this form had to be recognized. It was not possible to increase the number of stay rods without making the inside of the boiler inaccessible and without seriously increasing the weight.

To take steam of 60 lbs. pressure and upwards cylindrical boilers were introduced. Some of these had two furnaces and some three.

Then in order to get low boilers of this cylindrical form they were made double-ended with a central combustion chamber. The weight of such boilers including the water in them was about $1\frac{3}{4}$ cwts. per indicated horse-power. As working pressures of steam went up to 120 or 150 lbs. per square inch the locomotive type of boiler was introduced with closed stokeholds and a forced fan draught.

In all these boilers of various types there were tubes, through which the heated gas passed, which increased the heating surface of the boiler, the tubes giving off heat as they conducted the flame and gas through the body of the water. These tubes were

not very effective because the motion of the hot gas was parallel to the surface of the tubes.

A great change was then made by carrying the water in the tubes and allowing the hot gases to act upon the outsides of the tubes. This is the water-tube boiler.

Patents for this system of boiler, commonly known as the water-tube system, were taken out in 1850 for the Générateurs Belleville.

In 1855 M. Julien Belleville had succeeded in perfecting a boiler of this type; *i. e.* a type "*ayant pour seule circulation dans un tube en serpentin, placé audessus ou autour du foyer et formant un parcours ascendant.*" He had at any rate so far succeeded that in 1855 it was fitted in a French ship of war—the corvette "La Biche" of 200 horse-power. The tubes employed were welded and not solid-drawn tubes, only welded tubes being attainable in France at that date.

The "Biche" was furnished with four boilers of this type, but the tubes gave trouble, opening at the welds after a certain number of successive dilatations and contractions, and there were incessant leaks of tubes. This type was further tried and then definitely abandoned in 1859. At that date the manufacturers "*laissant de côté le principe de la circulation unique dont il avail jusque—la poursuivi l' application, adopta le principe des appareils a circulation multiple, qui est aujourd ' hui celui de la plupart des chaudières à tubes d' eau, actuellement en pratique.*"

Many successive models, differing from each other, were created in 1862, 1868, 1872, 1876, 1889. The model of 1889 obtained the grand prix in the Universal Exhibition in Paris at that date.

M. Julien Belleville claims to be the first to create

and realise in water-tube boilers the essential combination necessary for their proper working.

The successors of M. Julien Belleville designed in 1894 the boilers fitted in H. M. S. "Sharpshooter." This ship of 746 tons displacement and of $18\frac{3}{4}$ knots speed was fitted with eight Belleville boilers giving a total power of 3,600 horses. In the meantime the French Navy put these boilers into the armoured cruisers "Latouche-Treville," "Chanzy," and "Amiral Charner" and a number of similar ships. The ironclads "Brennus," "Charlemagne," "Saint Louis," "Bouvet," "Gaulois," and many large cruisers also received Belleville boilers. Some large ships of the Messageries Maritimes were also fitted including the "Australien," "Polynésien," "Armand," "Béhic," and "Ville de la Ciotat." "La Tamise" for the Dieppe and Newhaven Channel service designed for 21 knots speed was fitted with Belleville boilers to generate 4,500 horse-power, as were also the large United States packets "North West" and "North Land" of 7,000 horse-power. The Russian Imperial Yacht "Standart" had Belleville boilers for 15,000 horse-power and the Russian cruiser "Rossiya" for 14,500 horse-power.

In the Royal Navy of Great Britain the boilers were adopted in the "Powerful" and "Terrible," cruisers, to generate 25,000 horse-power. Each of these ships has forty-eight boilers. The large French ironclad "Brennus" has only 32 and the "Charlemagne," "Saint Louis," and "Gaulois" only 20.

The ships in the British Navy fitted and fitting with this boiler are as follows. The indicated horse-power of the ship is added. "Aboukir," 21,000; "Albemarle," 18,000; "Albion," 13,500; "Bacchante," 21,000; "Bedford," 22,000; "Berwick,"

22,000; "Bulwark," 15,000; "Canopus," 13,500; "Cornwall," 22,000; "Cornwallis," 18,000; "Cressy," 21,000; "Cumberland," 22,000; "Donegal," 22,000; "Drake," 30,000; "Duncan," 18,000; "Essex," 22,-000; "Euryalus," 21,000; "Exmouth," 18,000; "Formidable," 15,000; "Glory," 13,500; "Goliath," 13,500; "Good Hope," 30,000; "Hogue," 21,000; "Implacable," 15,000; "Irresistible," 15,000; "London," 15,000; "Kent," 22,000; "King Alfred," 30,-000; "Leviathan," 30,000; "Lancaster," 22,000; "Monmouth," 22,000; "Montague," 18,000; "Ocean," 13,500; "Russell," 18,000; "Sutlej," 21,000; "Venerable," 15,000; "Vengeance," 13,500; "Andromeda," 16,500; "Argonaut," 18,000; "Ariadne," 18,000; "Amphitrite," 18,000; "Arrogant," 10,000; "Condor," 1,400; "Diadem," 16,500; "Encounter," 12,500; "Europa," 16,500; "Fantôm," 1,400; "Furious," 10,000; "Gladiator," 10,000; "Hermes," 10,000; "Highflyer," 10,000; "Hyacinth," 10,000; "Mutine," 1,400; "Niobe," 16,500; "Powerful," 25,-000; "Rinaldo," 1,400; "Rosario," 1,400; "Sharpshooter," 3,500; "Shearwater," 1,400; "Spartiate," 18,000; "Terrible," 25,000; "Vestal," 1,400; "Vindictive," 10,000.

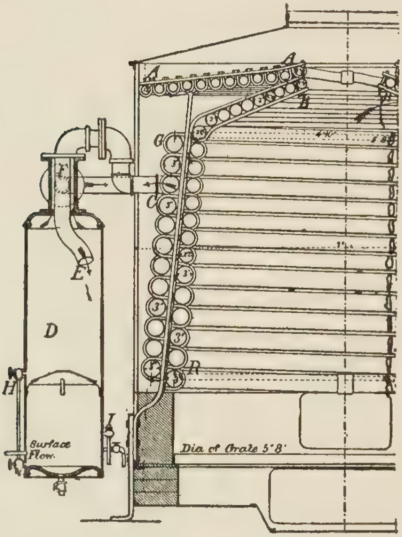
While the water-tube boiler was being developed in France, as narrated, it attracted much attention in the United States and in 1878 the Messrs. Herreshoff of Bristol, Rhode Island, had succeeded in making a successful boiler for small vessels in which they employed a single coil of wrought iron pipe two inches in diameter and 300 feet long for a 16 knot torpedo boat, 60 feet long. Feed water was pumped slowly through the coil and was converted into steam before it reached the end of the coil.

A drawing of this boiler is annexed because it is in-

HERRESHOFF STEAM GENERATOR

From Engineering, Feb'y 7th, 1879.

A. Feedwater Heater.
B. Main coil through which water descends.
C. Outer coil through which ascending steam and water rise.
D. The Separator.
E. Discharge pipe into separator.
F. Steam passage to drying coil G.
H. Water Gauge.
I Surface Blow-off.



teresting as having been the first successful water-tube boiler ever used in the British navy.

In 1878 the British Admiralty ordered the boat of which particulars are given of Messrs. Herreshoff, and Mr. John Herreshoff delivered it at Deptford in January, 1879. The boat did all that was promised on her trials.

That the boiler required careful watching by skilled persons was soon proved. The boat was accepted and removed to Portsmouth with cautions that the contractor, Mr. Geo. Dunell, should be informed when any trial was to be made. The sailors and engineers at Portsmouth decided to try the "new fangled thing" themselves without giving notice: the upper part of the coil became over-heated, through defective circulation, and there was a rupture of the tube. Some vedette boats were subsequently ordered of Mr. Herreshoff and gave satisfaction.

In the meantime Mr. Thornycroft and Mr. Yarrow noted that their performances in the corresponding 60 feet boats built of steel had been excelled in this roughly built but exceedingly clever and successful construction of wood and steel. Each of these engineers thereupon designed a water-tube boiler as an improvement on that of Mr. Herreshoff.

In 1885, the Admiralty ordered of Mr. Thornycroft a second-class torpedo boat with his new water-tube boiler to be tried against a similar boat with a locomotive boiler.

These were known as second-class torpedo boats 99 and 100. The last named of these had the water-tube boiler.

The boats were 64 feet long, eight feet broad, and had a displacement of 13.2 tons. The result was as follows:

	Locom. boiler.	W.-tube boiler.
Heating surface in sq. feet	265.5	606
Grate surface in sq. feet	6.94	8.5
Working pressure in lbs	130	145
Total weight (dry) tons	2.88	2.42
Weight of water, tons	.68	.64
Total weight including water, tons	3.56	3.06
Horse-power developed	174	196
Speed of boat in knots	16.13	16.81

This English boiler was so successful that Mr. Hereshoff had the mortification to receive orders to fit Thornycroft boilers in boats built by him for the United States navy. Mr. John Herreshoff is one of the world's great men and can afford to have a wholesome check occasionally without the risk of imperilling his fame.

But in the interval between the fitting of this English boiler in 1885 and the fitting of "Sharpshooter" with the Belleville boiler in 1894-5 the water-tube boiler question slept in England.

The crisis had, however, come. *Engineering* of July 22, 1887, says "The Spanish torpedo boat 'Ariete' with Thorneycroft water-tube boiler achieved the unprecedented speed of 26 knots on her trial trip. There is no doubt that this excessive speed was due in a large measure to the boiler with which this vessel was fitted."

But the British Admiralty did not see until later that a time for definite trials of the water-tube boilers had arrived and the public was unprepared for the great plunge into a new system in 1894-5 when the boilers of the "Terrible" and "Powerful" were fitted on the Belleville plan.

Between the dates of the trials of the "Ariete" in 1887 and of the adoption of the Belleville in the "Sharpshooter" in 1894 the navy might have been prepared for the change. The change was inevitable but it was certainly made without reckoning upon the possible attitude of the working engineers and stokers in the Navy to a system which enormously increased their cares and responsibilities.

The British Board of Admiralty was eventually obliged in deference to public opinion to appoint a committee to consider certain questions respecting modern types of boilers for naval purposes. This committee appointed in September, 1900, were informed that the points on which they should report were as follows:

"To ascertain practically and experimentally the relative advantages and disadvantages of the Belleville boiler for naval purposes as compared with the cylindrical boiler.

"To investigate the causes of the defects which have occurred in these boilers and in the machinery of ships fitted with them, and to report how far they are preventable either by modifications of details or by difference of treatment, and how far they are inherent in the system. The Committee should also report generally on the suitability of the propelling and auxiliary machinery fitted in recent war vessels and offer any suggestions for improvement; the effect as regards weight and space of any alterations proposed being stated.

To report on the advantages and disadvantages of the Niclausse and Babcock and Wilcox boilers compared with the Belleville as far as the means at the disposal of the Committee permit, and also to report whether any other description of boiler has sufficient

advantages over the Belleville or the other two types above mentioned as a boiler for large cruisers and battle-ships to make it advisable to fit it in any of Her Majesty's ships for trial."

In February, 1901, the Committee presented an interim report to the following effect:—

"The Committee are of opinion that the advantages of water-tube boilers for naval purposes are so great, chiefly from the military point of view, that, provided a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in His Majesty's navy than the cylindrical type of boiler.

"The Committee do not consider that the Belleville boiler has any such advantage over other types of water-tube boilers as to lead them to recommend it as the best adapted to the requirements of His Majesty's navy.

"The Committee recommend:—

(a) "As regards ships which are to be ordered in the future:—That Belleville boilers be not fitted in any case.

(b) "As regards ships recently ordered, for which the work done on the boilers is not too far advanced:—That Belleville boilers be not fitted.

(c) "As regards ships under construction, for which the work is so far advanced that any alteration of type of boiler would delay the completion of the ships:—That Belleville boilers be retained.

(d) "As regards completed ships:—That Belleville boilers be retained as fitted.

"In addition to the Belleville type of boiler, the Committee have had under consideration four types of large straight tube boilers which have been tried in war vessels and are now being adopted on an extended scale in foreign navies. These are:—

(a) "The Babcock and Wilcox boiler.

(b) "The Niclausse boiler.

(c) "The Dürr boiler.

(d) "The Yarrow large tube boiler [(a) and (b)] have also been tried in our own navy with satisfactory results and are now being adopted on a limited scale.

"If a type of water-tube boiler has to be decided on at once for use in the navy, the Committee suggest that some or all of these types be taken.

"Evidence has been given before the Committee to the effect that three most important requirements from the military point of view are:—

(a) "Rapidity of raising steam and of increasing the number of boilers at work.

(b) "Reduction to a minimum of danger to the ship from damage to boilers from shot and shell.

(c) "Possibility of removing damaged boilers and replacing them by new boilers in a very short time and without opening up the decks or removing fixtures of the hull.

"These requirements are met by the water-tube boiler in a greater degree than by the cylindrical boiler, and are considered by the Committee of such importance as to outweigh the advantages of the latter type in economy of fuel and cost of up-keep.

"The Committee consider the following points in relation to the construction and working of the Belleville boiler to constitute practical objections of a serious nature:—

(a) "The circulation of water is defective and uncertain, because of the resistance offered by the great length of tube between the feed and steam collectors, the friction of the junction boxes, and the small holes in the nipples between the feed collector and the

generator tubes, which also are liable to be obstructed, and may thus become a source of danger.

(b) "The necessity of an automatic feeding apparatus of a delicate and complicated kind.

(c) "The great excess of the pressure required in the feed pipes and pumps over the boiler pressure.

(d) "The considerable necessary excess of boiler pressure over the working pressure at the engines.

(e) "The water gauges not indicating with certainty the amount of water in the boiler. This has led to serious accidents.

(f) "The quantity of water which the boiler contains at different rates of combustion varying, although the same level may be shown on the water gauges.

(g) "The necessity of providing separators with automatic blow-out valves on the main steam pipes to provide for water thrown out of the boilers when speed is suddenly increased.

(h) "The constant trouble and loss of water resulting from the nickel sleeve joints connecting the elements to the feed collectors.

(i) "The liability of the upper generator tubes to fail by pitting or corrosion, and, in economiser boilers, the still greater liability of the economiser tubes to fail from the same cause:—

(j) "Further: The up-keep of the Belleville boiler has so far proved to be more costly than that of cylindrical boilers; in the opinion of the Committee this excess is likely to increase materially with the age of the boilers.

(k) "The additional evaporating plant required with Belleville boilers, and their greater coal consumption on ordinary service as compared with cylindrical boilers, has hitherto nullified to a great

extent the saving of weight effected by their adoption, and, in considering the radius of action, it is doubtful whether any real advantage has been gained. The Committee are not prepared without further experience to say to what extent this may not apply to other types of water-tube boilers."

Six members signed this report. The seventh member reported further as follows:

"Although the Belleville boiler has certain undesirable features, I am satisfied, from considerable personal experience, and from the evidence of engineer officers who have had charge of boilers of this type in commissioned ships, that it is a good steam generator, which will give satisfactory results when it is kept in good order and worked with the required care and skill.

"I am also satisfied, from my inspection of the boilers of the Messageries Maritimes Company's S. S. 'Laos,' after the vessel had been employed on regular mail service between Marseilles and Yokohama for more than three years without having been once laid up for repairs, that, with proper precaution, the excessive corrosive decay of the tubes which has occurred in some instances can be effectually guarded against.

"Having in view the extent to which Belleville boilers have already been adopted for His Majesty's ships, and the fact that there are now three or four other types of water-tube boilers which promise at least equally good results, I am of opinion that, pending the issue of the final report of the Committee, Belleville boilers should not be included in future designs. At the same time, I see no necessity for delaying the progress of ships which have been designed

for Belleville boilers in order to substitute another type of boiler."

M. Bertin in his well known book *Chaudières Marines* (Translation by Leslie S. Robertson. John Murray, London), says:—

"That in the French navy it has been found that a combination of cylindrical and water-tube boilers works satisfactorily and he foresees the introduction of water-tube boilers into the Mercantile Marine in this manner."

The gain in weight by the several steps is shown by M. Bertin in his tabular information from which the following is taken:

Single-Ended Return-Tube Boilers.

Indicated horse-power.		Total weight of boilers including water. (Tons.)	Weight per horse power. (Lbs.)
6,982 ...	"Bretagne" } Merchant ships.	1027.	329.6
7,148 ...	"Gascogne" } Merchant ships.	1055.	330.6
6,351 ...	"Sfax"	493.5	174.0
8,332 ...	"Amiral Baudin"	621.2	167.0
8,048 ...	"Isly"	542.8	151.

Double-Ended Boilers.

10,892 ...	"Cécile"	661.2	137.8
11,990 ...	"Capitaine Prat"	628.1	117.8
13,324 ...	"D'Entrecasteaux"	722.6	121.7

Locomotive Type.

518 ...	Torpedo boats	12.89	55.76
1,944 ...	"Bombe"	49.07	56.57
1,668 ...	"Achéron"	84.69	113.7

Belleville Type.

Indicated horse-power.		Total weight of boilers including water. (Tons.)	Weight per horse power. (Lbs.)
8,202 ...	"Alger"	437.5	119.5
13,817 ...	"Bouvet"	580.38	94.1

D'Allest Type.

9,106 ...	"Jemmapes"............	402.78	99.1
9,832 ...	"Chasseloup-Laubat"...	373.28	85.
14,803 ...	"Carnot"...............	591.45	89.5
9,376 ...	"Du Chaylor"..........	378.93	90.5

Niclausse Type.

9,438 ...	"Friant"...............	363.19	86.2

Normand Type.

1,176 ...	Torpedo boats....	15.21	29.

It is not reasonable to propose that water-tube boilers should be abandoned because they give trouble. All boilers give trouble. The original flat boilers were always a source of trouble from deformation and leakage. If steam were not got up very slowly in them, troublesome and often serious leakage followed. Then, too, like all boilers, they were liable to burst open and the amount of water suddenly flashed into steam made a burst a matter of vital consequence to the ship.

The cylindrical boilers in their turn gave in the

British navy the most serious trouble through leaky tubes.

The water-tube boiler has so many advantages in minimising the consequences of a rupture; in the rapidity with which steam can be got up, and in lightness, that it is sure to make its way.

CHAPTER VIII.

GUNS.

THE first guns devised for getting a horizontal fire with shells were made in 1821-2. Before that date shells or bombs had been thrown from mortars. A 13-inch bomb weighed when empty, 100 lbs. and had a bursting charge of 6 lbs., 2 ozs. It was fired with 20 lbs. of powder from a mortar weighing five tons. The mortar rested on a bed of timber weighing another five tons. Mortars were fired at about 45° elevation, and at a range of 2½ miles they would break through any roof or any deck. At a range of one mile, and with an elevation of 42°, the point which the bomb would strike could be foretold within 150 feet.

In 1824 some guns of 50 cwt. to throw 8-inch shell, and of 85 cwt. to throw 10-inch shell were tried. Such shells were soon found to be so destructive, when exploding between the decks of a ship, that they were at once provided for ships of war by all the maritime powers.

After this, Mr. Martin introduced a hollow shot filled with molten iron. A 10-inch shot contained 40 lbs., and an 8-inch, 25 lbs. of this fiery liquid metal.

Shells fired from a 68-pr. containing 26 lbs. of molten iron were fired at the "Undaunted" an old 44-gun frigate. Five were fired at distances between 200 and 350 yards. Nos. 1 and 3 broke up, charred

the deck, and set the lining on fire. No. 2 did not break but became red hot and set fire to the frames in which it lodged. Nos. 4 and 5 broke up. Immediately afterwards dense smoke came from the shot holes, and from the hatchways of the ship. In six minutes the ship's fire engines were at work but the men who worked them could not endure the heat and smoke for five minutes. Fire floats failed to extinguish the fire and the ship was sunk by firing six 68-℔. shot between wind and water.

Shells, and shot filled with molten iron, were so formidable against wooden ships that it was seen to be necessary to take some means to meet them. Col. Paixhans had stated years before this that the proper answer was to make the ship proof against artillery by an iron cuirass. A French committee was appointed to consider the proposal. The publication of these facts led the English government to design some iron vessels for war service. The French decided not to do so.

In 1842 experiments were made by the Admiralty to ascertain whether wrought iron plates of $\frac{3}{8}$-inch thickness riveted together so as to make up a thickness of six inches, were ball proof, experiments previously made in America, by Mr. Belmeno, having been reported to be proof against 32-prs. and 8-inch shell guns.

Admiral Sir Thomas Hastings reported that as the result of the Admiralty experiments, wrought iron plates six inches thick made up of sixteen plates three-eighths of an inch thick and fixed over the planking of a ship's side, would give no protection at 400 yards against shot fired with 10 ℔s. charges from 8-inch guns and heavy 32-prs. It may be added, he said, that supposing that they would, they could not well

be brought into use, because the weight of the top-works would be so much increased by the addition of such iron plates that the velocity of steamers, the velocity and stability of sailing ships, and the qualities of each class as sea-boats, would be so materially injured, as to render this measure impracticable.

In 1846, other experiments were made by the Admiralty, with the "Ruby" iron steamboat of 73 tons.

Capt. Chads reported as follows:—

"The shot going through the exposed or near side generally makes a clean smooth hole of its own size, which might be readily stopped; and even where it strikes a rib it has much the same effect; but on the opposite side all the mischief occurs; the shot meets with so little resistance that it must inevitably go through the vessel, and should it strike on a rib on the opposite side the effect is terrific, tearing off the iron sheets to a very considerable extent; and even those shot that go clean through the fracture, being on the off side, the rough edges are outside the vessel, precluding the possibility almost of stopping them.

"As it is most probable steam vessels will engage directly end-on I have thought it desirable to try to-day what the effect of shot would be on this vessel so placed, and it has been such as might be expected, each shot cutting away the ribs, and tearing the iron plates away sufficient to sink the vessel in an instant.

"The 10-inch shot for example with 12 ℔s. of powder passed through the bottom plates on one side, struck a rib on the other side, and made a hole four feet long, three plates wide."

In 1849, ordinary iron plates were tested against musketry, canister and grape shot. It was found that a plate less than $\frac{3}{8}$-inch was penetrable by a musket at 40 yards. That a plate less than $\frac{1}{2}$-inch was penetra-

ble by 32-pr. canister at 100 yards: and that $\frac{3}{4}$-inch plate was penetrable by 32-pr. grape at 200 yards. Also that the relative resistance of iron and oak plank, were nearly the same as their specific gravities; viz. one to eight, $\frac{1}{8}$-inch of iron being equal to one inch of wood.

The report in this case was against the use of iron for the bottoms of ships and in favour of its use for the upper parts.

It said:—1. "Shot of every description in passing through iron make such large holes that the material is improper for the bottoms of ships.

2. "Iron and oak of equal weight offering equal resistance to shot, iron for the topsides affords better protection to the men than oak, as the splinters from it are not so destructive.

3. "Iron offering no lodgment for shells in passing through the side, if made with single plates, it will be free from the destructive effects that would occur by a shell exploding in a side of timber."

In 1850, the investigation advanced another stage by experiments made with two targets each ten feet square made exactly like the "Simoom" at the wales, as to plates, ribs, and security (the plates being $\frac{5}{8}$ thick); but the inside planking and the occasional filling-in pieces of oak between the ribs were omitted. These sections were placed 35 feet apart to represent the two sides of the ship. Between the targets a screen of 1-inch fir boards was placed to ascertain the severity of the splinters, and another of extended canvas to ascertain their number.

The guns and charges used were such as the steamers then carried; viz. 32-pr. with 6 to 10-℔s. charge, and 8-and 10-inch hollow and solid shot with 10 and 12-℔s. charges.

The report was, "The result of these experiments is the reverse of those made in the 'Ruby' in 1846, a small slight built iron vessel, when the great damage was found to be sustained on the shot passing out on the opposite side of that fired at, making clear round holes only on the first side. On the present occasion, the resistance being so much greater, the principal injury has been to the front side; and the fractures made are of that description, that two or three shot and sometimes even a single one striking under the water-line must endanger the ship. There is also another most serious evil attending this greater resistance which was not anticipated and which has caused great surprise. The shot or shell in striking are shivered into innumerable pieces, passing on as a cloud of langrage with great velocity, sufficient to pass through the inch fir boards, the larger pieces going 400 or 500 yards, and some through the other target making large irregular holes; this would be most destructive, and I firmly believe men could not stand behind it."

These experiments, Capt. Chads considered, proved that whether iron vessels are of slight or substantial construction, iron is not a material calculated for ships of war.

A final experiment was then made to ascertain whether by filling in between the iron frames with oak and working 4-inch oak planking on the inside the severe splintering would be modified. It was reported that:

1. "The holes made by the shot are not so irregular as on the former occasion but are clear and open; all parts of the shot passed right through the iron and the timber and then spread abroad with considerable velocity, parts of the iron plates and a few

very small pieces of shot were sometimes retained in the timber.

2. "With low charges the shot did not split into so many pieces as before.

3. "With high charges the splinters from the shot were as numerous and as severe as before, with the addition in this, and in the former case, of the evils that other vessels are subject to, that of the splinters from the timber.

"*From these circumstances I am confirmed in the opinion that iron cannot be beneficially employed as a material for the construction of vessels of war.*"

This led to the condemnation of a fleet of iron ships, 17 in number, which were either fitted or in course of preparation as vessels of war. They were:—

IRON SHIPS IN 1850.

	Guns.	Tons.
"Simoom"	18	1980
"Vulcan"	14	1764
"Greenock"	10	1418
"Megæra"	10	1554
"Birkenhead"	5	1400
"Trident"	6	850

and 11 smaller vessels, carrying guns.

Thus on entering on the Russian war it had been decided that ships of war must be built of wood, unprotected by iron, as even six inches of iron placed on the wood failed to protect it.

The favourite guns were therefore shell guns. The armament of a three-decker of 121 guns, consisted of one-half 65-cwt. shell guns, and one-half 32-prs. with one 68-pr. pivot gun. The shell guns were placed on

the lower and middle decks. In a two-decked ship the lower deck was armed throughout with shell guns, and the other decks with 32-prs. of from 42 to 58 cwt. The main deck also was sometimes partially armed with shell guns.

It was during the Russian war in 1854-5 that Capt. Cowper Coles mounted a 68-pr. gun upon a raft of casks. The raft called the "Lady Nancy" was much approved of by Lord Lyons, and Capt. Coles was sent home to assist in devising means for mounting and training heavy guns. There was no turntable on this raft, and no armour. Capt. Coles did not propose a turntable for a mounting until some years afterwards.

The "Lady Nancy" raft was approved because of its lowness and smallness of mark, its light draft, its steady platform and the facility it gave for training the gun.

The "Monitor" was designed by John Ericsson to be shot and shell proof, and to obtain this protection he thought it necessary to make the amount of surface to be protected a minimum. The only portion of the ship which should be elevated was the battery. A round battery, enclosing a gun and slide, was the most economical arrangement possible, and this must be capable of revolving.

The subsequent development of the turret under the direction of Capt. Coles, and afterwards by the adoption of hydraulic machinery for controlling it, as devised by Sir W. Armstrong's firm, was purely English.

In August, 1861, the Armstrong breech-loading guns in the navy were the 100-pr., total length 10 feet, and weight just over four tons; the 40-pr., of the same length, and a little over one and a half tons; the 20-pr., $5\frac{1}{2}$ feet long, and a little over half a ton in

weight. Besides these there were 12-prs., and 6-prs.

The "Warrior" and other ships were armed with some of these 100-prs., and with 68-prs. The pivot guns were mounted on slides and the broadside guns on rear-chock carriages with directing bars.

The ammunition applied to the "Warrior" was as follows:—

				Rounds.
Shells	Filled	Common	100 prs	100
		"	40 "	80
		Segment	100 "	100
		"	40 "	60
	Empty	Common	100 "	100
		"	40 "	80
		Segment	100 "	100
		"	40 "	60
Shells	Filled		68 prs	340
Shot solid			100 prs	100
			40 "	200
			68 "	2380

Mr. Longridge, in a letter to the Secretary of State for War written in 1882, summarises the history of the breech-loading gun up to the date of his letter. Mr. Longridge was a rival inventor, but he was a member of the Institute of Civil Engineers, and knew his facts well.

"After the helter-skelter rush," he says, "into Armstrong breech-loaders, which, between 1858 and 1862, cost the country two and a half millions sterling—not with the approval of many who had made the subject their special study, but against their opinions and remonstrances—it was found as had been predicted, that these guns, though possessing some excellent qualities, had—to use Sir J. Adye's words—a trick of 'getting out of order at critical moments, and accidents occurred to the men that worked them.' 'The officers

and men lost confidence in these weapons, and were as anxious to get rid of them as they had been to obtain them.'

"The anxiety to obtain them is a matter we must take upon trust; of the anxiety to get rid of them there is no doubt.

"Then came the so called 'careful enquiries,' limited, however, almost entirely to the systems of the two rivals, Armstrong and Whitworth, the long-continued and, in my opinion, very uninstructive competition in 1863, the trials in 1864 and 1865, and the Committees appointed from 1868 to 1870, resulting in an unanimous opinion of the said Committee that a muzzle-loading system ought to be introduced. Thus after many years investigations, and the expenditure of many millions sterling, we found that they were all wrong, and had to begin again. During all this long period critics were pooh-poohed, outside inventors were kept at arm's length, and Woolwich and Elswick reigned supreme.

"But at last, in 1870, all was to be put right, and for ten years again millions of money were expended in the new muzzle-loading armament.

"Then again began doubts and fears, to what extent called forth by those troublesome Germans, with Herr Krupp at their head, I know not; but at length those doubts and fears have culminated in the new discovery that we are again all wrong not only that muzzle-loaders are a mistake for heavy ordnance, and breech-loaders the thing, but that even the muzzle-loaders, built at such enormous cost, were ill-designed and inefficient, and that it is possible to make even muzzle-loaders of the same weight nearly double the power of those on which we have spent so much time and money. Thus we are again on the eve of a period of

reconstruction. We are to have guns of a new type, and, are told by Sir John Adye, probably new ships to carry these new guns. The outlook is grave, in all truth, and it is not at all strange if we feel somewhat shaky in our faith in these new-type guns and their makers."

In 1870 various kinds of stud shot were under trial adapted to the rifling of the muzzle-loading guns and designed to prevent the rapid erosion of the grooves.

In 1876 the naval ordnance forming the armament of H. M. Ships consisted mainly of wrought iron muzzle-loading guns. Of these there were two kinds of 38 tons, one of 12½-inch and the other of 12-inch, two kinds of 12-inch guns, one of 35 tons and another of 25 tons; two kinds of 25 ton guns, one of 12-inch; and one of 11-inch, one of 10-inch (Mark II.); one of 9-inch (Mark VI.); one of 8-inch (Mark III.); two of 7-inch (Mark III.) and (Mark I.). There were four kinds of 64-prs. The highest muzzle velocity which had been obtained from any of these was 1,420 feet per second. The most powerful breech-loading guns in use in the ships was a 4-ton gun, and the highest velocity obtained from a breech-loading gun was 1,193 feet per second.

Cast iron smooth bore guns (68-prs., 8-inch, and 32-prs.) were still mounted in some ships. There was also the wrought iron smooth bore 100-pr. of 6¼ tons which gave the highest initial velocity of any of these guns—1,700 feet per second.

The various large guns in course of manufacture for the navy at the end of 1876 were as follows:—

LARGE NAVAL GUNS AT END OF 1876, ALL MUZZLE-LOADERS.

Inches.	Tons.	Ft. long.	Lbs. projectile.	Lbs. charge.	Foot-tons per inch of shots circumference.
17	100	33	2000	341	585
16	80	26¾	1700	370	548
12½	38	19	800	200	360
12½	38	19	800	130	300
12	35	16	700	110	220
....	25	....	600	67	....
....	18	....	400	60	....
....	12	....	250	43	....

In August, 1878, experiments made with some recently manufactured M. L. guns at Elswick showed that considerably greater effects could be produced with lighter guns. Sir Wm. Armstrong said they had a new gun of 8-inch bore weighing $11\frac{1}{2}$ tons, and firing a projectile weighing 180 ℔s., with a maximum charge of 95 ℔s.: this would give a velocity of 2,116 feet per second, equal to a penetrative power of 222 foot-tons per inch of shot's circumference, which was in excess of that produced by the 35-ton gun. A reduction of weight from 35 tons to $11\frac{1}{2}$ tons has been obtained without loss in armour-piercing power. The loss in smashing or breaching power was of course very great. Sir Wm. Armstrong also said that they had at Elswick, nearly ready, a breech-loading gun of equal power and dimensions. This date, August, 1878, marks the first step towards realizing the long cherished desire of Sir Houston Stewart to get rid of the muzzle-loaders. At this date there was at Elswick a 12-inch muzzle-loading gun of 40 tons in progress

which was expected to rival the piercing power of the new 80-ton gun.

It was seen that as the perforating power of the guns and the greater range of the projectiles were likely to be more highly esteemed in the navy than smashing power, with lower velocities, it would follow that the size of future ships in relation to the power of their armaments, might be greatly reduced, and that the value of side armour would be lessened. The possibility of introducing these more powerful muzzle-loading guns into the "Ajax" and "Agamemnon" and "Colossus" and "Edinburgh, " then building, was at once considered.

An alternative proposal was then made by the Ordnance Department for a new 10-inch muzzle-loading gun, chambered to give increased velocities. The gun proposed was 19 feet long, of 20½ tons weight, with a charge of 100 to 115 pounds of powder; the expected gain in power was 33½ per cent over the service gun.

It appears that as early as 1873 experiments had been made by the Ordnance Department, for chambering guns to obtain higher velocities, but difficulties arose and the subject dropped.

The Armstrong proposal was for a 38-ton muzzle-loading gun with a projectile of 640 lbs. a velocity of about 2,000 feet per second and with a gain of penetrative power upwards of 50 per cent over the short guns of 38 tons preparing for these ships.

In November, 1878, a model was prepared showing how these long muzzle-loading guns might be loaded if employed in turrets of the size of those in the "Ajax." The great disadvantage would be that, at quarters and in action, the four loading chambers and the two ports of each turret must be permanently open, and there-

fore subject to the invasion of the sea, if it gets upon the deck.

In December, 1878, it was decided not to delay the "Ajax" and "Agamemnon" any longer. The change to longer guns and breech-loading, or to loading long muzzle-loaders outside the turret, involved large considerations which could not be disposed of hastily; and the long guns were not yet made, and were of course untried. It was settled that the ships must be completed for the 38-ton gun chambered as then arranged. The hydraulic gear for mounting these guns was then proceeded with.

A few months later the work was again suspended pending the result of enquiry at Malta as to the explosion of the 38-ton gun of the "Thunderer." In April, 1879, a committee was appointed to consider the questions then before the Heavy Gun Committee and the question of breech-loading guns was to be included.

In August, 1879, the Admiralty approved of long breech-loading guns mounted in turrets for the "Edinburgh," "Colossus," and "Conqueror," with arrangements for opening and closing the breach and for loading, as shown by Sir Wm. Armstrong in December, 1878, and they so informed the War Office.

At this date the War Office decided to manufacture a 12-inch rifled breech-loading gun in accordance with a Woolwich design. In May, 1880, a 43-ton breech-loading gun was ordered from Sir Wm. Armstrong as an experiment, to be delivered in ten months. In August, 1880, the War Office was told that the limit of length of gun admissable in the "Edinburgh," "Colossus," and "Conqueror" was 27¾ feet, but that in the "Collingwood" any reasonable length could be adopted.

In July, 1880, it was finally decided that the 43-ton guns of the "Colossus," "Edinburgh," and "Conqueror" were to be breech-loading.

In January, 1881, it was proposed to raise the charge for these guns from 285 lbs. prismatic powder, to 400 lbs. of slow burning powder. On the 16th March, 1881, the first 43-ton gun, manufactured at Woolwich, was tried at Shoebury. On the 18th January, 1882, the Elswick 43-ton gun was tried at Woolwich. On the 17th February, 1882, the design for 43-ton guns for the "Colossus," "Edinburgh," and "Conqueror," was approved. The weight of the projectile was decided upon, 29th September, 1883; and the weight of the charge on the 15th March, 1884.

The building of these ships had been commenced as follows:—"Edinburgh," March, 1879; "Conqueror," April, 1879; "Colossus," June, 1879.

In 1886 Lord Ravensworth asked in Parliament "for what purpose the 'Colossus' was to be sent to sea; what trials or tests the 43-ton guns of the 'Colossus' had been subjected to since the bursting of the 'Collingwood's' 43-ton gun on May 4th, and what were the orders given to the officer appointed to the command of the 'Colossus' with regard to the use or abstention from use of the ship's guns. A very great deal of interest had attached to the 'Colossus' from the day when she was first designed. She was laid down exactly seven years ago, and therefore it could not be said that the Admiralty had shown any great precipitancy in sending the ship to sea. She was one of the first ships built with steel-faced armour. She had two turrets in which she carried four steel breech-loading guns. She carried also five 6-inch guns, ten Nordenfelts, and some Gardner guns. Both in her offensive and defensive aspect she was one of the most

powerful iron-clads afloat. He wished to draw attention to the remarkable history of the 43-ton guns which she carried in her turrets.

"In 1882, the authorities at the Royal Arsenal recommended the abandonment of wrought iron in the construction of heavy ordnance for the navy, and supplied a design for the construction of a steel breech-loading gun. There were in this country men who for their long attention to the delicate question of the right construction of heavy ordnance were second to none, and these refused to manufacture guns upon that design. They objected to the construction of the gun and also to the mode in which it was proposed to manipulate the working of the steel. He was informed upon indisputable authority that steel was at its best when it approached nearest to wrought iron, and that if it departed from the condition of 'low' steel and was worked up to being 'high' steel it might be stronger but it was more brittle. For gun manufacture the nearer it was kept to those qualities possessed by wrought iron the better. It was a remarkable circumstance that about the time that doubts arose both in regard to the design and the material of these 43-ton guns there were five in hand, but the authorities were not content with completing these, which, having regard to the money already spent upon them, was reasonable enough, but they ordered six others to be manufactured. These 43-ton guns were originally designed to carry a charge of 400 ℔s. of powder. This was subsequently reduced to 290 ℔s., and even with this it was found that after 16 rounds they jammed, and the charge was then reduced to 222 ℔s. which was the charge in the gun which burst on board the 'Collingwood.' He should like to hear from the noble Marquis what trials and what

tests these guns had been submitted to since that lamentable accident." To this the Marquis of Ripon replied:—

"In regard to the 43-ton guns he thought it was desirable that the public should clearly understand the question raised by the bursting of the gun. It applied only to a particular class of the 43-ton gun. The 43-ton guns which were now being manufactured and which would be hereafter delivered to the navy were of an improved pattern and were not, as the best authorities believed liable to the objections urged against this particular class of gun. He should like to mention also that the 43-ton gun of the 'Colossus,' although of the same description as those of the 'Collingwood,' had passed through more trials than those of the 'Collingwood.' The guns of the 'Collingwood' had only been tried at proof. It was the opinion of many naval men that in regard to those guns the particular danger arose especially in connection with the first round of fire after proof. Whether that was so or not he could not say, but that was the opinion held. Doubts had been thrown, and reasonably thrown, upon this particular class of 43-ton gun in consequence of what happened the other day on the 'Collingwood.' He and his colleagues immediately after the accident communicated with the War Office with the view of seeing whether these guns could not be replaced. The Admiralty was not responsible for the construction of these guns: the War Office was responsible; and it was only fair to the Board of Admiralty who were concerned in this matter that he should mention the fact. On enquiry he ascertained that the War Office were making and would soon complete 43-ton guns for land service, made upon an improved principle and not liable to many of the objec-

tions which had been urged to the 43-ton guns (Mark II.). He therefore went to the Secretary of State for War and asked him to supply those guns for the navy. Looking at the circumstances of the case his Right Hon. friend at once agreed to do so. The guns, however, were made with trunnions and would require to be altered. They would be ready at once, and he was informed that in three or four months at the outside the whole of the guns would be placed at the disposal of the navy. Six of these guns would be supplied to the navy. Besides that it was intended to chasehoop the 11 guns referred to by the noble Lord, and he had already ordered two new guns of the very latest and best pattern. He had under consideration whether the Admiralty should order some more of these guns, although they would not be completed for 12 or 14 months. He hoped in consequence of the arrangement which he had been able to make with the War Office that the navy would receive six 43-ton guns of a satisfactory kind within a period of not more than four months. It was true that in these circumstances, and looking to the fact that the 'Colossus' was going to sea for the purpose of thoroughly testing her sea-going qualities, as a matter of precaution the Admiralty had directed the captain not to fire these 43-ton guns at target practice. He hoped that before the cruise was finished those guns would be replaced by the other and more satisfactory guns to which he had referred."

Some idea may be formed from this brief history of the difficulties attending the preparation of modern ships for their guns. The statesman who in 1884 expressed his doubts as to the direction in which money could be best spent upon the navy showed by his doubts that he knew more and not less than those who were provoked by his prudent policy. The bold

confession of his doubts marks his honesty and his courage.

The carriages and mountings are an even more troublesome item in modern construction. "In 1862," says Commander Dawson, "when I ceased to be senior lieutenant of the School of Gunnery at Devonport, the standard broadside guns were those of 58 cwt. and 65 cwt. worked on antiquated truck carriages by fourteen men. Those who have, in former days, worked the officer's gun at first quarters in the 'Excellent,' may remember the exhaustion incidental to the jerking action, both on the handspikes and on the tackles, in dragging the gun round the sweep piece to different bearings beyond the 'wooding' point. On the 'Cambridge' broadside was a 95-cwt. gun on an equally barbarous rear-chock carriage, which 22 stalwart seamen, urged to their utmost powers, vainly strove to train with rapidity equal to that of the 65-cwt. guns, and after breaking most of the gear, the attempt had to be abandoned. The principal slide gun of that period was the 68-pounder of 95-cwt., a good shooter, most unsafely mounted. A single rope on either side, and a single whip in rear, formed the running-in gear. The carriage was not tied down to the slide, nor was the slide tied down to the deck. The compressors did not control the movements, except when set up for actual firing. And when the ship was in lively motion at sea, it was highly dangerous to cast off the lashings so as to use the gun. For, whilst in the fore and aft position, the gun might capsize or fetch way, and in the attempt to run it in, to shift the pivots or to load, there was a constant peril that in a quick roll it might break loose from all control. These slide guns, therefore, were seldom used in a sea-way, and

when they were, it was no small relief to all concerned when they were again firmly lashed to the decks and bulwarks. Captain Preedy's evidence, in 1865, as to similar slides for the 6½-ton guns on the 'Hector,' is applicable to both weapons, 'The other day we had great difficulty in running the gun in, with 22 men on the train whips and tackles attached to the carriage, the ship heeling over 6°; but the fact of firing the gun, I have no doubt, would have brought it in. Why I alluded to running in was this, the ports of these iron ships are low, and if you get a gun out and cannot get it in again, it would be a serious matter in a sea-way.' Rear-Admiral G. T. P. Hornby stated, in 1865, that Captain G. O. Willes, having cast loose, for exercise in a sea-way, a 6¼-ton gun so mounted, the gun was unmanageable, and the men were afraid to go near it. Any experienced naval artillerist who will carry his thoughts back seven years, will wonder at the hardihood of Captain Willes in attempting in a sea-way, to cast the lashings off the slide guns of that period. So unsafe were the gun slides then in use, that ships so provided were virtually disarmed by a moderate swell of the sea, as reported by the late Admiral Warden and the captain of the 'Lord Clyde,' so late as 1866."

Gun mountings have passed through many changes since that date. Captain Coles, Admiral Robt. Scott, Mr. Vavasseur, M. Canet, Sir Wm. Armstrong and Co., Sir Joseph Whitworth & Co., and the Vickers Firm have all contributed to the final result which is that every gun is absolutely under control. Even the 110-ton gun mounted in the "Sans Pareil," and the new guns of less weight in the barbettes of other ships, are worked in a sea-way without any difficulty.

THE GUNS AT THE CLOSE OF THE CENTURY.

	Calibre in Inches.	Weight in Tons.	Length in Feet.	Weight of Projectile. lbs.	Muzzle Velocity in Foot Seconds.
British.......	16.25	110½	43⅝	1800	2087
British.......	13.5	69 & 67	36	1250	2016
British.......	12	45 & 46	27½	714	1914
French.......	13.39	52.9	39	220.5	2400
German......	12	35.4	21.98	725.3	1713
Russian......	12	55.7	30	731.9	1942
United States	13	60.5	40	1100	2100

Of the quick-firing guns the 6-inch Admiralty gun fired ten rounds in 85 seconds. The 8-inch 15½-ton gun fired four rounds in 22 seconds with ammunition supplied from magazine.

The 37-m. m. gun fires one pound projectiles at the rate of 300 per minute.

The 57-m.m. fires 6-lb. projectiles at the rate of 28 per minute and is capable of perforating 7.9 ins. of wrought iron at the muzzle. The 4-inch gun fires 25 lb. projectiles at 15 rounds per minute and has a perforating power of 14 ins. of wrought iron at the muzzle. The 8-inch gun fires a 250 lb. projectile at the rate of five rounds per minute. Its perforating power is 28½ ins. of wrought iron at the muzzle.

The accompanying paragraph on the gun-power of cruisers taken from *Engineering* gives the most recent views of gunners in England.

"In connection with the launch of the first class armoured cruiser 'Euryalus' from the Naval Construction Works of Messrs. Vickers, Sons, and Maxim, Limited, at Barrow-in-Furness, on Monday last, the question was raised as to the gun-power of cruisers generally, a subject which is of primary importance,

in view especially of the effective equipment of Russian and French commerce destroyers, in which, as a rule, gun-power has more attention than protection. The 'Euryalus' and her sister-ships mark an important advance, as compared with the vessels of the 'Diadem' class, because they are not only faster and have an armoured belt in addition to a protective deck, but they are fitted with the latest 9.2-inch guns, one each at bow and stern, in addition to twelve 6-inch quick-firers divided along the broadside, including four available for firing ahead in line with the keel and four for firing astern. The Vicker's mounting of the 9.2-inch guns is also a special feature, and while hydraulic appliances have been fitted, the whole mechanism is so balanced that it can be easily rotated by manual labour, although it weighs 120 tons, so that in the event of the fracture of the hydraulic piping, or any of the mechanical gear being disabled, the guns can still be rotated and elevated easily. Thus, in the convenience of arrangment and in ballistics, a great improvement has been made upon the 'Diadem,' which had two 6-inch guns placed side by side forward and aft, where the one 9.2-inch weapon is now installed. The time has come when a change has to be made in the direction of increasing the range and power of the cruiser's guns. The 9.2-inch weapon of the Vicker's type, fitted to the 'Hogue' and 'Euryalus,' has a total muzzle energy of 19,209 ft-tons, while the 6-inch guns have a muzzle energy of 5,340 ft.-tons; the British service weapons fitted to the earlier ships had only an energy of 3,356 ft.-tons. Thus, as compared with the 6-inch weapons of the 'Diadem,' the one 9.2-inch gun has an energy six times greater, and although there were two 6-inch where there is now only one 9.2-inch, there is great advantage in

being able to strike such a blow as is possible with the larger gun. It is just in this direction that advance is likely to be made, because a ship likely to bring into action a few very long-range guns may do very considerable damage to a commerce-destroyer eager to escape with her superior speed from a slower enemy; and thus the time has come when the 7.5-inch gun must be adopted in addition to the 9.2-inch in large ships, and as a substitute for 6-inch guns in smaller ships for use in bow and stern-chasers. This 7.5-inch gun, which has been supplied by the Vickers Company, and has passed through successful trials in the service, has a muzzle energy of 11,825 foot-tons, as compared with the 5,340 foot-tons of their 6-inch guns, so that with four for bow and stern use, as well as for firing on the broadside, even a moderate-sized cruiser would be able to do first-class execution against a heavily-armed ship, because of the long range of these 7½-inch guns. As to the rapidity of fire, the smaller gun discharges eight rounds per minute, and the larger weapon six rounds per minute, so that from all points of view the 7.5-inch gun is well worth the slight addition to weight which its installation would involve."

CHAPTER IX.

RAMS, TORPEDOES AND TORPEDO BOATS.

M. DE BLOCH in his address on War at the Royal United Service Institution in London on the 1st July, 1901, said that, "Formerly there were no means of constraint but force; to-day if there existed an arbitral tribunal whose judgments could be carried out by excluding a recalcitrant from the benefit of the international conventions war would become impossible. That was the reason why armaments formed a crime against humanity. The greatest service, therefore, that could be rendered to humanity was to study profoundly the new conditions of war and the results to be hoped therefrom. When all were convinced of the impossibility of deciding international quarrels by means of war, disarmament would be imposed gradually by the force of things."

M. de Bloch has become famous by his able advocacy of the position that the perfection of military weapons has made it impossible to appeal to war on land as a means of settlement of the grave questions which have hitherto been so settled. It is understood that his labours had much to do with the action of the Czar of Russia in bringing about the Hague Conference.

Certainly the experiences of war in South Africa go far to affirm his contentions as to the enormous losses which great bodies of men massed together may suffer

at the hands of small bodies of well armed and mobile enemies. Whether this will have the effect of discrediting the old modes of massing men for attack and defence remains to be seen. We are not here concerned with that question but with the bearing of M. de Bloch's contentions on naval war.

In the formation of war navies it has been held for many years past by some naval officers and naval architects that the massing of men and material in ships and in fleets was impolitic. Many mobile units with free personal initiative were, it was contended, to be preferred to a less number of very large ships. Suppressing the personal initiative of a number of highly trained officers in ships under the command of one man who absolutely limited and controlled the action of the subordinates was held to be unwise. The further grouping of such large ships in fleets under a single command was, it was urged, no longer justifiable seeing how great was the attacking power which might be used effectually by a few men.

The navy differs from the army in this important respect that a large naval force once concentrated in one unit cannot be broken up. The huge ship once created remains, and if used at all must be used as a fully manned huge ship. And a fleet once brought into action under the Vice-Admiral commanding the fleet cannot be detached from the flag and the ships made to work on independent lines without confusion and disaster. And whatever M. de Bloch may say as to the great power which is now put into the hands of a few men on the land, applies with much greater force on the sea.

When it was first proposed to revert to the use of the ram in naval warfare men objected that it was an ungallant form of attack; the torpedo was held to

be a devilish invention, and torpedo inventors and torpedo boat builders were no better than assassins. A little reflection will show that this is not so. M. de Bloch tells us why it is not. The perfection of the weapon tends to make war impossible. If ships could be attacked under water as easily as a few Boers with long range rifles and smokeless powder can attack a body of soldiers, maritime war could not be waged. Fleets would disappear and there would remain only the commando raised for an occasion; and these commandos would be formed out of the ordinary peaceful elements of a mercantile marine.

For the present it is much more difficult to assail big ships at sea by means of small ones than it is to punish a large land force massed together, by means of a hastily levied well armed and very mobile non-military force. But the agents are at work which will perhaps bring about the gradual approximation of operations on land and on sea.

The chapter on Mercantile Auxiliaries shows what has been done to gradually introduce the new elements into state navies and at the same time to prepare for the eventual disappearance of the huge fighting ship, designed only for fighting, and of the fleets composed of many fighting ships worked together.

One of the author's greatest personal efforts was to endeavour to get the ram recognised, as a proper weapon of war and to secure its introduction into every ship of war. And he further was instrumental in the creation of vessels of small size and of speed superior to the battle-ships of the time, the sole or principal weapon in them being the ram. The "Polyphemus," one of these, was intended to be a Ram and not a combined Ram and Torpedo ship. Admiral Sir George Sartorius, who greatly interested himself in

the "Polyphemus," lost his interest in her when it was decided that she should be armed with Whitehead torpedoes, as well as with the ram and with the means of defence against boat attack. The introduction of torpedoes made the ship far more costly than she need have been and it is possible that the type would have been continued and improved had the simplicity of the ram been adhered to.

The submarine attack whether by ram or torpedo is incomparably more dangerous than the above water attack. It is so dangerous that it was long thought to be impossible to save a ship which should be once fairly struck by ram or by torpedo. But great attention has been bestowed upon subdivision of the underwater hulls of ships of war and it has been hoped that ships might be so designed that could not be fatally injured by a single blow whether delivered by gun, by ram, or by torpedo. It was considered that H. M. S. "Victoria" was so designed. Her consort and almost sister ship the "Camperdown" struck her fairly with the ram. The blow was one of those smashing underwater blows which had been held to be necessarily fatal. The bulkhead arrangements in the "Victoria" did not save her because they were rendered inoperative by open doors in the bulkheads. The report on the disaster justified the provision made by showing that the ship would not have sunk had the doors been closed either before or immediately after the collision.

The first torpedo tried against ships was one towed astern of the attacking ship. It was known as the Harvey torpedo and was so worked that when the ship to be attacked was just being passed by the attacking ship the towed torpedo was partly released so as to cause the resistance of the water through which

it was towed to force it out sideways towards the ship to be attacked. The torpedo thus met the stern or the bow of the ship and was made to explode on contact. This was succeeded by a much superior weapon known as the Whitehead torpedo. This may be regarded as a shell fired from a gun, for such it is. But it is much more than this. On reaching the water into which it plunges soon after leaving the gun it acts as a submarine ship propelled by a marine engine and a screw propeller. It travels at high speed in the direction in which it has been discharged and presumably straight for the ship which it is to attack. On striking the ship an apparatus known as the whiskers fires the explosive charge. If this charge were fired when the whiskers were in contact with good armour at or just below the water-line but little damage would be done. The blow must be struck below the armour, or not less than, say, six feet under water. There is equilibrium apparatus in the torpedo which being set for a given depth under the water first brings the torpedo up after its dive and then settles it at this fixed depth so that the torpedo, when once settled, runs a level course until it meets the soft bottom of the ship some ten or twelve feet under water.

Every part of the torpedo was exposed to the view of the gunners when the torpedo was opened except the levelling apparatus. The balance chamber in which it operated was sealed and could be inspected only by certain confidential officers to whom by agreement Mr. Whitehead communicated the secret. They were pledged by solemn agreement, between Mr. Whitehead and the contracting government not to communicate the secret even to the admiral in command of the fleet. This solemn agreement was entered into by one European government after another

at the time when the contract was made. Long after every maritime power had purchased the secret these confidential officers remained the sole possessors of it.

The next step was to provide small fast vessels capable of discharging these missiles under cover of darkness or smoke. It had been taken for granted for generations that small vessels could not have such high speeds as were attainable by large ones. The torpedo boat in the hands of M. Thornycroft dispelled this illusion. The first torpedo boats designed employed a more simple form of torpedo than the Whitehead. The bursting charge was fixed to the end of a long manageable spar which was thrust over the bows of the boat and under the bottom of the ship attacked. This was known as the spar torpedo. The use of this torpedo was attended with such risk on the part of the assailants that it was soon superseded by the boat fitted with one or more guns or tubes from which the Whitehead torpedo might be discharged.

Some of these boats were so small that they could be hoisted on board a ship and stowed and carried there until the time came for putting them to use. These boats weighed about twelve tons and were 60 feet long and had a speed of 16 knots an hour. Larger and faster boats were then produced which could not be hoisted into ships and which attained a speed of over twenty knots an hour. Eventually a class of vessel was produced larger and faster than any torpedo boat, and armed with guns for destroying torpedo boats, as well as with torpedoes for attacking ships. These are known as Destroyers. Ships have also been specially designed to form a home or centre for such vessels, carrying several torpedo boats on their decks, and having on board a repairing factory for the vessels and their machinery.

There is still another kind of torpedo boat—the submarine boat. Such a boat was built by Mr. J. Scott Russell on the Thames in 1854 under the authority of Prince Albert and Lord Palmerston. It was built secretly, and the fact that it had been built, had been sent to Portsmouth, and had come up under the bottom of a merchant ship there, much to the surprise of both parties, was not commonly known until years afterwards.

Quite recently this experience was repeated with one of the most modern of submarine boats. The officer in command had been operating in the harbour without the knowledge of the officers of the ships of war lying there. Desiring to ascend he found that something was wrong and that the more ballast he discharged the more firmly he appeared to be fixed. Meanwhile the captain of one of the large ships finding something strange and unfamiliar was going on beneath his ship, telegraphed to ask if the torpedo boat was out. Learning that she was, he let go his moorings and shifted his position, thus releasing the prisoner which speedily jumped up in the water beside him.

But the submarine boat has come to stay. A nation like France, threatened with the blockade of her principal ports, will strain every nerve to perfect this under water attack, by which she may at least make blockading too perilous a business to be lightly undertaken. That she has had some success may be seen by the records of the proceedings of these boats.

"Two French squadrons the Mediterranean and the Northern were operating in the Mediterranean in July, 1901. During the operations the Gustave Zédé suddenly turned up in the port of Ajaccio, unheralded but safe and sound, and so completely in

fighting trim, in spite of the long voyage from Toulon, that she dared even to torpedo the battleship Jauréguiberry as the latter was leaving her moorings. The unexpected arrival of the submarine created consternation. She had passed nearly the whole day at sea out of sight of land. She left Toulon in company with a tug and may for a time have utilized the assistance this furnished in order to economize her store of electricity. But she arrived, at all events, quite alone at Ajaccio with enough electricity at her disposal to torpedo one of the enemy's vessels. She entered the bay of Ajaccio completely submerged, sighted by none of the signal-stations, and was thus able to traverse the entire line of war vessels in the bay." So runs the report in the London *Times*.

Thus on the sea we are preparing for some such surprises as those which befell the British generals on the land in South Africa.

In addition to mobile torpedoes the ships endeavouring to enter an enemy's port are threatened with stationery torpedoes either discharged on contact or by means of an electric current directed from the shore. Such entrances are thickly planted with submerged mines and countermining is one of the common operations in which seamen are practised. They carry in light boats a string of mines. They force or find their way into the mined area and sink lines of torpedoes to a desired and fixed depth below the surface. These are then exploded and all mines lying within range of the explosion will themselves explode or be disabled, thus leaving a passage up which the ships may pass.

CHAPTER X.

ARMOUR.

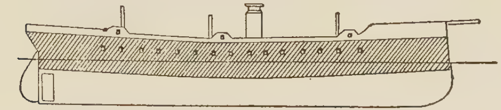
The sketches on page 170 show the first arrangement of armour in sea-going ships built of wood.

In contrast with it see the arrangement of armour in the "Majestic" and "Magnificent" class.

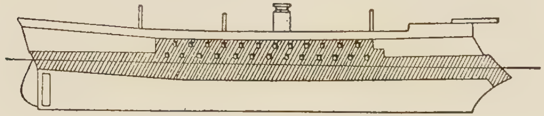
During the period marked by continual increases in the breaching power of the guns and in the resisting power of the armour the use of large guns in some few ships was favoured as being the best way to stop the desire for thicker armour.

In a paper before the Royal United States Service Institute in about 1882, the author said he did not believe that increases in the calibre and weight of guns would tend to thicken armour. The result of the contest would, he believed, be that armour would finally disappear as side plating for the hull of the ship, and that where it must continue to be used for the protection of the gun and its mounting it would improve in quality, so as to be impenetrable to shell, however made. The principal projectile must be shell, and we shall probably find ourselves, he thought, with steel defences of excellent quality, but of very limited extent, over our gun mountings; and the smallness of their size and their impenetrability to shell will practically leave them unassailed, while the upper works of the ship, above the shot-proof deck are attacked by shell. This is in fact just what has

The first French armoured Ships of 1858: Gloire, Normandie, Invincible, etc.
Armament 36 Guns of 5 tons. Scale 15 in. 10,000.

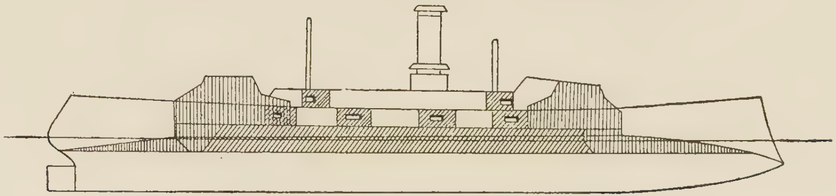


The Magenta and Solferino of 1859. 52 Guns of 5 tons.



H.M S. MAGNIFICENT

Arrangement of armour: on barbettes 14 in., on belt 9 in.



Scale, one-half that of the French Ships.

ARMOUR ON BATTLESHIPS.

happened as may be seen by looking through the designs for modern ships given in Brassey's *Naval Annuals*.

One thing remains to be said. The effect of smashing blows upon thin armour may turn out to be very disastrous. The armour is hard and resists perforation, as glass will, but it is probably no better against smashing blows than the softer armour was. Twenty years ago it was the known effect of heavy breaching blows, not of perforation, which occasioned anxiety. There appears to be no such anxiety now, but it is not quite clear why there is not. In the French ship "Dupuy de Lôme" for example, there is a very large surface of thin shell-resisting armour. This armour is believed to be proof to special high explosive shell; it may be so, and that is a great point gained. But this large area of thin armour invites the attack of solid shot, and of projectiles from guns of much larger calibre than 4-inch, which is the thickness of the side armour.

The example of the French is being widely followed, and we are seeing once more large areas of thin armour which must be attacked by smashing shot or by large shell. It must be expected that when the high explosive shell is stopped by thin Harveyed armour an attempt will be made to break into the shield and its supporting structure by heavier or better projectiles, and to wreck what cannot be pierced. If it should be said these shells are now more to be dreaded than any wreckage of an armoured side, it appears to be a fair question whether it would not be better to limit the destructive area of these exploding shell by partitions and screens, rather than to put up against them structures which invite smashing blows and will

become when smashed, the most terrible of missiles as they are driven in fragments across the decks.

Since the first armoured ship was launched at Brest in 1858, it has been held by high authority on both sides of the Channel that clothing ships with armour was a vain device, and that the fashion would pass away; that the resistance of the armour would be over-mastered by the gun; and that new modes of attack would be devised against the large portions of the ships necessarily left unarmoured. But the armour has held its place, although it has undergone many changes under the stress of the attack upon it. It increased in thickness from four inches to as much as 24 inches. It changed its character from forged iron, to steel-faced iron, and then to forged steel. It sought to evade direct attack by change of position, and took to covering the decks instead of the sides. In some form or other it has held its ground, and every ship of war has armour. No one builds unarmoured ships for war service, except where the vessels are too small to be able to bear even a thin protecting deck. Armour has come to stay. Armour-plate-making is a firmly established industry. The industry has had its vicissitudes, and it is better not to enquire too curiously as to how many times it has had to change from one form of costly plant to another.

For a long time shipbuilders and artillerists could not agree as to the comparative merits of compound armour (iron at the back and steel at the front) and armour wholly of moderately carburized steel. They are all agreed now that it must be wholly of steel, highly carburized, and hardened on the face. The Schneider system, making the whole plate of one large ingot, has prevailed, and the English building-up

plan has been beaten out of the field by the aid of American ingenuity and enterprise.

The improvement in the resisting power of armour which has been brought about during the last ten years is stated to be more than 50 per cent. When wrought iron was in use, before Mons. Schneider gave us steel plates, 22-inch armour could be perforated by good 12-inch projectiles; and 19-inch armour by 9.2-inch projectiles. Now, in plates of average thicknesses (six inches to 12 inches) the best projectiles require a diameter at least equal to the thickness of the plate which they are required to perforate. Six-inch plates will resist perforation from a 6-inch projectile fired at 1,960 feet velocity per second. A plate 10½ inches thick has resisted well a 9.2-inch projectile with 1,800 feet velocity. This plate had already received five rounds of 6-inch projectiles with velocities of about 2,000 feet per second. None of these latter made more than a splash upon the plate. The projectiles go to pieces against these new plates. But the newest guns, with modern powder, are quite capable of doubling the energy of the projectile, and it is important to consider whether the projectiles hitherto produced would be capable of using up this energy. No doubt increased velocities may secure perforation, although the punch may go to pieces. It has been found, for example, that projectiles which with 2,000 feet velocity did no serious damage to the plate could be forced through the plate in pieces when the velocity was raised to 2,400 feet per second.

May it not be that, as against hardened plates, shot which will pulverize are less suitable for high velocities than shots made of more ductile material, which will submit to a moderate flow of the steel during the instant that perforation is being effected? It appears

to be useless to double the energy upon a punch which goes to pieces with the energy already commonly employed. Eager seekers after improvements in plates, in which there is keen rivalry, are likely to overlook that other department of their works where the projectile is made. It is to war officers and marine arsenals rather than to contractors that we must look for improvements in shot.

Increase in the size of ships of war is largely dependent upon this relative advantage of the armour over the gun. So long as armour is believed to be capable of resisting perforation attempts will be made to cover larger portions of the ships with it, and the larger the ship the more easy it is to cover her sides with armour impenetrable to the average gun. With armour in the ascendant ships will grow in size; with guns in the ascendant numbers of ships rather than large ships will come into favour.

While this advance in the quality of armour has been in progress other causes have favoured the use of thin armour. The quick-firing gun has greatly increased the power of an enemy to disable the crew working in above-water unarmoured places; and the use of shells charged with melinite, or other high explosives, has still further increased the power of the attack on these parts of the ship. We have witnessed, therefore, during the last few years, the growth in the navies of Europe of opinions unfavourable to large guns and thick armour. How great this change of opinion has been may be realized by recalling a few facts.

Among the officers in the British navy who had the best opportuntities for studying the question of armour against guns was Admiral Sir John Hay. He said in 1873, "If the armour is not impenetrable then

it is worse than useless." At the same date Vice-Admiral Touchard, a most distinguished officer in the French navy, said, "Of what service then is this cuirass from the moment when it is penetrated? Far from being a protection it is a danger." In 1876 Admiral Sir Geo. Elliot circulated in Parliament a pamphlet designed "to stop the useless expenditure by the Admiralty of vast sums of money on the ships ordered by them" not because the ships were partially unarmoured, but because they were armoured at all. In that pamphlet he declared armour-clad ship-building to be the result of want of foresight, for which, he was willing to admit, there was some excuse. But he contended that the evidence of the superiority of the gun, and the developments of the efficacy of the ram and the torpedo had deprived us of sufficient excuse of late years to continue to fight the losing game of armour against guns.

So late as 1881 the general view as expressed by the late Signor Brin, the celebrated designer, and more recently the Italian Minister of Marine was as follows: "It is not then the size of an iron-clad which makes her formidable: it is not by the number of her guns that we must reckon the power of a man-of-war, but rather by the weight of the projectile she can fire at each shot from each gun."

We know how unfashionable these views are now. We have naval officers in England whose whole thought seems riveted upon the quick-firing gun. But it needs to be remembered that the quick-firing gun is either not under the cover of armour at all, or it is incompletely covered by very thin armour, and it may be silenced by corresponding fire from the adversary. The same may be said, generally, of the high-explosive shell guns.

As against the efficient heavy armour-piercing projectile there is no defence, except thick armour; and a single perforation of this armour will produce the disastrous wreck with which some of us were so familiar at Gavre, Spezia, and Shoeburyness. And behind this armour lie the vitals of the ship which a flying fragment of plate may instantly disable.

It is the fashion to say that the rapidity of the blows and the volume of the fire which can be delivered in a given time are the important factors in each ship. This might be so in duels, and in fleets composed only of ships designed for duelling, with nearly equal speeds, armour, and armament; but if one fleet should have guns in some of its ships capable of perforating the thickest armour of the adversary, and the adversary should have no such guns, it would take much hard fighting on the part of the latter to redress the inequality. These questions are pushed out of sight while the armour-piercing projectile remains shorn of its power of mastery. Restore it to its proper position and we shall learn once more that while the ram and the torpedo may be avoided or mastered, the gun cannot be, and that destruction is borne, inevitably, upon the wings of the well-directed shot. The result would be the immediate return to smaller ships and smaller crews.

What is most important in the progress which has been made in guns is set forth in the last volume of Brassey's *Naval Annual* where the effects of the fire of high explosive shell upon H. M. S. "Belleisle" are shown.

The conclusion reached by Lord Brassey is as follows:—

"The 'Belleisle' experiments demonstrated most forcibly that armour gives most efficient protection

against shell-fire, and that the unarmoured parts of a ship are hopelessly untenable under the fire of a number of quick-firing guns."

There were no quick-firing guns in the Russian batteries in 1854-5, but there were powerful shell guns. The British naval officers came home with this one demand, "For God's sake keep out the shells." During the last half century we have devoted ourselves to the task first of keeping out the shells from every part of the ship, then of saving ourselves from the worse evil of having our armour driven into our faces by armour-piercing projectiles. This we did by thickening armour in the more important places and leaving the less important unarmoured. Armour-piercing projectiles have now given place to quick-firing shells and the cry is once more, "Keep out the shells." Thin armour is again being spread out on the ships' sides as it was forty years ago. The gun will increase in penetrative and smashing power to meet it and we are apparently to go a second time over the old road.

CHAPTER XI.

THE MERCANTILE MARINE AND STEAM SPEEDS AT SEA.

The most striking way in which progress may be seen is not by setting forth the numbers of ships produced in successive eras although that would show rapidity of development in steadily increasing progression but rather by observing the progress in type in ships upon a certain principal route.

Mr. Arthur Maginnis in his recent book, *The Atlantic Ferry, its Ships, Men and Working* (Whittaker & Co., London and New York, 1900), has done this very admirably.

His interesting table of Atlantic records and events shows us that the first steamer crossed the Atlantic in 1819. This was the "Savannah," built in New York. She left New York for Liverpool on Monday, 24th May, 1819. She arrived at the mouth of the Mersey on Sunday, 20th June, 1819, a passage of four weeks.

The paddle wheels were made to turn in easily, there were no paddle boxes and the paddles could be secured on board in the space of twenty minutes and the ship was then propelled by her sails. The actual continuous working of the engines was only a little over three complete days out of the twenty-nine and a half days of the voyage. The reason for using the machinery so little was that the vessel had only 75 tons of coal on board for the voyage. The machinery was taken out in the following year and the vessel

was employed as a sailing ship until she was wrecked in 1822. It is estimated that her total weight or displacement was 1,850 tons and the indicated horse power of her engines about 90: her speed was about six knots and the expenditure of coal per hour a little over one-third of a ton.

The first passenger steamer crossed the Atlantic in 1838. She was the "Royal William" of the City of Dublin, Steampacket Co., despatched from Liverpool by the Trans-Atlantic Steamship Co. to New York. She attained a speed of about eight knots an hour. Her dimensions were 145 feet in length and 27 feet in breadth.

The first ship of the Cunard Line to cross was the "Britannia" in 1840. Mr. Cunard afterwards Sir Samuel Cunard came from Canada to England in 1839 and with Mr. George Burns of Glasgow and Mr. David MacIvor of Liverpool, arranged to run a trans-atlantic line of mail steam-ships from Liverpool to Halifax and Boston, fortnightly in summer, and monthly in winter. The British government subsidised this line with £81,000 per annum. She made the passage in 15 days. In 1844 this ship was frozen in by thick ice in Boston Harbour. The Boston people in order to free the mail packet cut a canal through the ice to the open sea seven miles long and 100 feet wide. She was released two days after her time for sailing. The British postal authorities offered to defray the expense of this unusual feature of navigation but the citizens of Boston declined to be reimbursed. It was agreed at the time that New York should have been the port for the mailpackets as the sea there never freezes.

This ship was 207 feet long and 34½ feet broad. This steamer with her sisters the "Arcadia," "Co-

lumbia" and "Caledonia" was built of wood at Port Glasgow by Robert Duncan & Co. The paddle engines by which they were driven were built by Robert Napier.

In connection with this venture we come upon a cluster of great names, the names of men who will always be famous for their work in naval development during the nineteenth century.

Then follows the Collins Line (an American Line, New York to Liverpool), (1850); the Inman Line (1850); the Allan Line (1854); the Anchor Line (1856); the National Line (1863); the Guion Line (1866); the White Star Line (1871); the American Line (1873). The first vessel of the Allan Line was the "Canadian" an iron screw propelled vessel, 278 feet long and 34 feet broad.

The first iron steamer which crossed the Atlantic was screw-propelled—the "Great Britain" which made her first passage in 1845. She was 274 feet long and 48¼ feet broad.

The engines of this ship were of 1500 I. H. P. The furnaces burned 65 tons of fuel per day. She had six masts, the second one from forward was the only one which was square rigged. She was built at Bristol in 1843 but was detained in dock for nearly 18 months waiting for the widening of the entrance to allow her to pass out. After making passages from Liverpool to New York in 1845-46 she was stranded on the coast of Ireland for an entire winter. From 1853 to 1874 she worked on the Liverpool and Australian trade as a four-masted ship square rigged on two masts. In 1882 she was changed into a full rigged sailing vessel. It is impossible to speak of this ship without recalling the name of the Engineer Brunel, who undertook the

construction of an Atlantic Liner in iron in 1845 and arranged that she should be screw-propelled.

The "Great Britain" was not a record breaker as to speed as the "Great Western" built at Bristol from Brunel's earlier designs was. This ship (the "Great Western"), built at Bristol by Patterson, in 1837, made the passage between Bristol and New York in fourteen days one day of which was lost by a stoppage at sea. The distance on the homeward passage was about 3,190 knots. Taking thirteen days for the passage this gives ten knots for an average. The ship must be credited with another knot or say eleven knots for a measured mile speed. This was a remarkable performance; for the highest speeds obtained by the mail steamers in the Dover and Calais passage in 1840 was only ten knots. This vessel is marked as a record breaker in speed in the diagram showing "The Victorian Expansion in Steam Speeds at Sea." The man who conceived the fast wooden paddle steamer the "Great Western," the strong iron "Great Britain," screw-propelled, for the Atlantic passage and afterwards the "Great Eastern," full of new and excellent structural devices, was indeed a great man.

Mr. Maginnis has prepared in tabular form a valuable mass of information concerning the advance made in Atlantic Navigation between 1840 and 1899.

The dates of typical ships in this period are as follows: 1840, "Britannia;" 1843, "Great Britain;" 1850, "Arctic;" 1855, "Persia;" 1858, "Great Eastern;" 1864, "Scotia;" 1869, "City of Brussels;" 1871, "Oceanic;" 1874, "Britannic;" 1875, "City of Berlin;" 1881, "City of Rome;" 1882, "Aurania;" 1883, "Oregon;" 1884, "America;" 1885, "Etruria;" 1889, "City of Paris;" 1890, "Teutonic;" 1893,

"Campania;" 1897, "Kaiser Wilhelm;" 1899, "Oceanic."

The lengths of the steamers steadily increase. The "Britannia" commences with 230 feet over all and the "Oceanic" closes with 704 feet. The "Great Eastern" breaks the continuity of progress in length. The first steel ship, the "Aurania," was also shorter than the iron ships "City of Berlin" and "City of Rome."

When steel was once taken up the advantages over iron were seen to be so great that all the succeeding ships except the "Oregon" were built of steel. The last of the wooden ships in this list was the "Arctic," in 1850. The last of the iron ships was the "Oregon," 1883. The last of the paddle ships in this list was the "Scotia," in 1864. The last of the single-screw steamers was the "Etruria," in 1885.

The indicated power of the propelling machinery was in the "Savannah" 90 horse-power; in the "Britannia," 740; in the "Oceanic," 29,000; and in the "Deutschland," 36,000.

The speed of the "Britannia" in 1840 was eight knots per hour, that of the "Kaiser Wilhelm der Grosse" has reached an average of over 22½ knots per hour on the passage. The "Britannia" burned 38 tons of coal in 24 hours, the "Kaiser Wilhelm der Grosse" burns considerably over 500 tons in 24 hours.

The first cost of one of these liners is now about three-quarters of a million sterling and we are told that the sum of £30,000 has to be realized on each trip before any profit is made by the owners.

This vast development comes within the century. Robert Fulton's steamer the "Clermont" first ran on the Hudson in 1807. Bell's "Comet" which was only 24 feet long was the first steamer on the Clyde and

she was the beginning of steam navigation. She was only of five horse-power and she could only run at the rate of five knots an hour in slack water. The Hoboken Steamer "Phœnix" was built by Robert L. Stevens in 1808 and she was the first to face the open sea. The first to cross the Atlantic was, as already said, the "Savannah" built by Fickett and Crocker of New York in 1819.

In the near future we may see a remarkable advance made on the lines proposed by the Hon. C. A. Parsons.

The latest step taken by him is announced in *Engineering* as follows:—

"Parson's steam turbine has long been recognised as an economical means of driving electric generating machines, and it has proved most satisfactory in the working of the propellers of torpedo-boat destroyers, adding greatly to their speed; but merchant ship owners have, as is usual, looked to others to embark on the initiation of the system for driving ordinary steamers. Under these circumstances, Messrs. Denny, of Dumbarton, who have ever been to the front in scientific shipbuilding work, joined with the Parsons Company, securing at the same time the co-operation of Captain John Williamson, long associated with the Clyde tourist traffic, and these three found the capital for the construction of the first steam turbine-driven merchant steamer, which has just been launched from Messrs. Denny's yard. Messrs. Denny have adopted a form and size of hull so as to get comparative results between two steamers, whose only difference is that one is paddle-driven, the other has propellers operated by turbines. The paddle steamer is the 'Duchess of Hamilton,' one of the most successful of the Clyde estuary steamers, and she steams 18 knots: the new ship named the 'King Edward' is to get 20 knots by

reason partly of the less weight of machinery. The vessel is 250 feet long between perpendiculars, 30 feet breadth moulded, and the depth to promenade deck is 17 feet 9 inches. She has three decks—lower, main, and promenade, the latter extending right fore and aft. A double-ended cylindrical boiler has been adopted for steam generation, and owing to the limited depth of a ship a separate uptake and funnel has been provided for each end. There are three steam turbines and three shafts, the high-pressure turbine driving the central shaft and the two low-pressure turbines those on either side. The centre shaft has one propeller, and the two side shafts two propellers each, so that there are five propellers in all."

The progress of the century may be set forth strikingly in relation simply to speed in steamships at sea. The author recently prepared for the Greenock Philosophical Society in the shape of a James Watt Anniversary Lecture some groups of interesting particulars on these lines. The author said to his Greenock audience:—

"In Westminister Abbey, in the little chapel of St. Paul, attention is arrested by Chantrey's famous statue of James Watt.

"It stands beneath the banners of forgotten nobles and knights, within arm's length of four famous tombs, over which it is uplifted. On one side is the beautiful tomb of the Daubenys, who died, husband and wife, near four hundred years ago. On the other is the tomb of Frances Sidney, Countess of Sussex, who was the pious founder of Sidney Sussex College, Cambridge. Immediately in front rests the body of Lord Keeper Bromley, who presided at the trial of Queen Mary Stuart, and died two months after her execution. Behind it is the monument erected in

memory of Lord Bourchier, who was made standard-bearer to King Henry V. for his exploits at Agincourt.

"The 'Deanery Guide' to the Abbey says that Chantrey's statue was just able to force its way through the doors, but the vaulting gave way beneath the weight, disclosing rows upon rows of gilded coffins. The good Dean who tells us this appears to doubt the wisdom of placing such an imposing statue in the narrow precincts of the Chapel of Henry VII.

"But James Watt loomed large upon the imagination of his countrymen when he died, eighty years ago, and has continued to do so ever since. 'He enlarged the resources of his country,' says the inscription upon the pedestal of the statue, 'and increased the power of man; the monument was raised, not to perpetuate a name which must endure while the peaceful arts flourish, but to show that mankind have learned to honour those who best deserve their gratitude.' So wrote Henry Brougham, with the full concurrence of the king, his ministers, and his people, in remembrance of the deeds of the citizen of Greenock whom we are assembled to-day to honour once more in his native town. That you do so continue to assemble is an even more remarkable testimony to his fame than is the colossal monument in the great Abbey.

"It is my desire, in responding to the gracious invitation of your Society to me to give this address, to follow your example by calling attention to what has been done in recent years by fellow countrymen of ours, and by men of other lands whom we equally honour, in 'increasing the power of man,' and enlarging his resources by the aid of the steam engine in ships, and especially in increasing speed at sea.

"On steam navigation generally, I would call your attention to its enormous expansion within quite re-

cent years. On the 21st January, 1867, my friend, Mr. John Scott Russell, gave the Watt Lecture here on the application of the inventions of Watt to modern steam navigation. Since that date the steam tonnage of the mercantile shipping of Great Britain has multiplied more than sixfold.

"In the Royal Navy there has been a sixfold increase in these thirty-two years. The effective horse-power of the steam ships in the Royal Navy was, in 1867, half a million. To-day it is, according to the Engineer-in-Chief, about three millions. If my old friend, Scott Russell, could be awakened from his dreamless sleep on that lofty hillside overlooking the English Channel at Ventnor, and could be told of this immense advance, I think that even he would find his most sanguine anticipations as to the future of steam navigation overpassed. If we ask the experts concerning the advances that have been made in engine construction during these thirty-two years, they will tell us that the pressures of the steam generated in the boilers have gone up in the largest ships from 30 lbs. per square inch to nearly 300 lbs. per square inch, that piston speeds have increased from 500 feet per minute to 900 feet per minute, and that the revolutions of the screw-propeller have risen in very large ships from 75 per minute to 120 per minute and in smaller vessels to 400 per minute. Mr. Scott Russell had considerable influence in settling the elements of the design of the steam frigate 'Warrior,' which is still upon the active list of the navy. We have recently been told by the Engineer-in-Chief of the navy that the steam machinery of the torpedo destroyers gives the same horse-power as the 'Warrior's' engines give, with one-seventh of their weight, and one-half the consumption of fuel.

"At the date of Mr. Scott Russell's lecture the

crack Cunarder was the 'Russia.' Her horse-power was 3,100, with a coal consumption of 3.1 lbs. for each horse-power per hour. To-day the crack Cunarders are the grand ships built on the Clyde, with engines developing nine times as much power, and with a coal consumption per unit of power only two-thirds of that in the 'Russia.'

"But to go back to earlier history, we may ask ourselves what were the speeds at sea which marked the supreme attainment, before the Greenock man took the matter in hand, and for many years afterwards? It is difficult to get precise information as to the highest speeds which were attainable under sail, because measured mile processes, had they existed, are not applicable, and also because lengths of passage on which we have to estimate the speed give averages which must have been considerably below the actual speeds through the water during exceptionally favourable runs. And it is these exceptional speeds which we need in comparing large and small ships for commerce and for war.

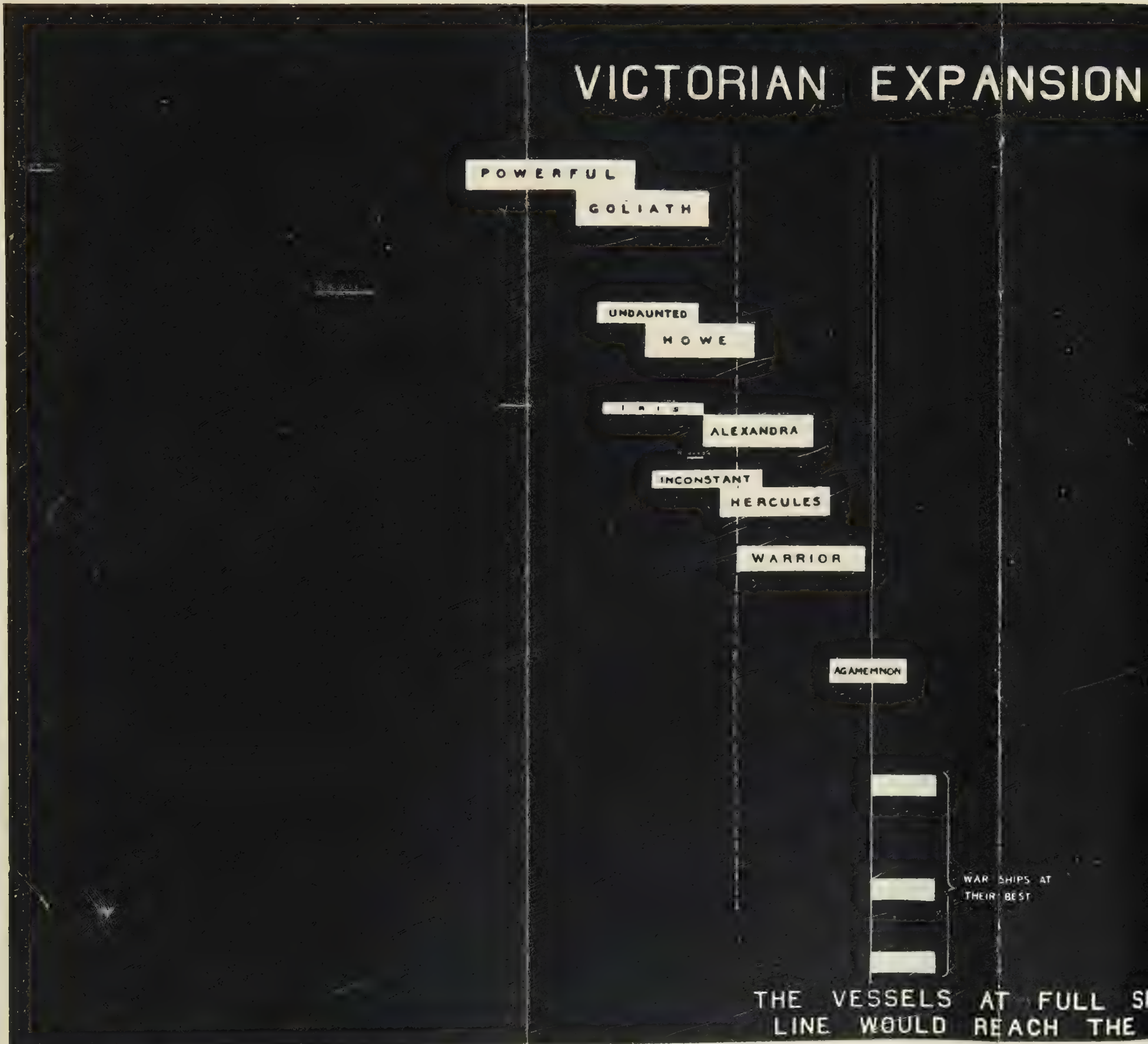
"I have been favoured with the opinion of the most experienced seaman of the old school still living among us, Captain Henry Moriarty, C. B., and he tells me as follows:—'Sail,' he says, 'would certainly beat the oars in boats, but I greatly doubt a speed of 13 knots, or anything like it, ever being attained by boats before the mighty power of steam was applied to them. The quickest run of which I ever remember to have heard, in the case of a ship, was from St. John's, Newfoundland, to Liverpool in about 1832. The vessel sailed on Sunday morning and the master dined with the Mayor of Liverpool on the following Sunday as an honour earned by his extraordinary passage. The distance from St. John's, Newfoundland, to Liverpool

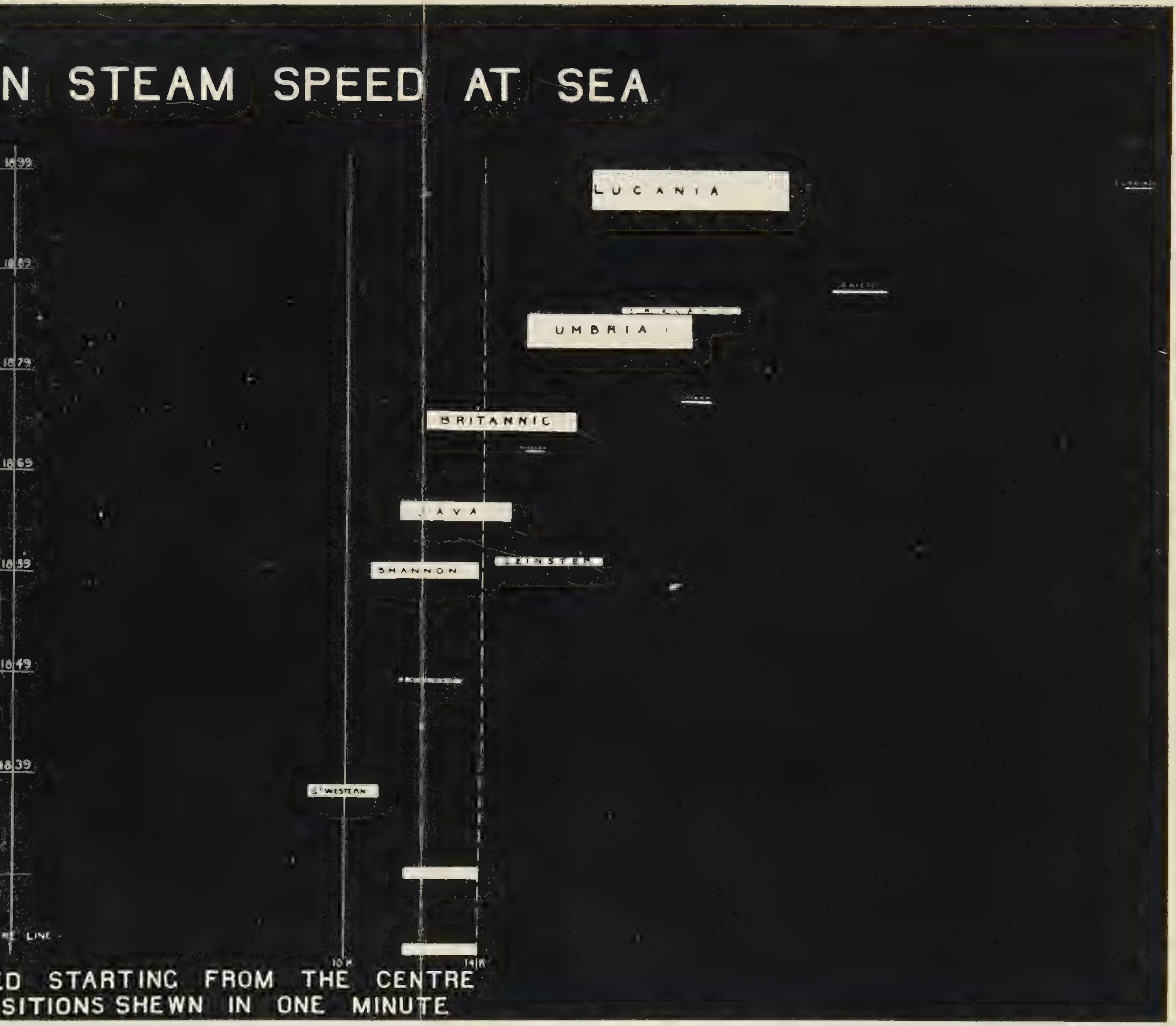
is about 1,974 miles from point to point, not allowing for a few miles up the river—on the other hand the ship may have been a few hours over the seven days. This gives an average of 11¾ knots an hour. Captain Moriarty thinks 14 knots may have been a little exceeded in the best parts of the passage. Sir William White says that there are several cases on record in which sailing yachts have attained speeds of 13 or 14 knots an hour. H. M. S. 'Inconstant' has made runs, he tells us, of 13½ to 14½ knots per hour under sail alone.

"These speeds may in exceptional cases of racing yachts have been somewhat exceeded, but we cannot set the speed at which any service can have been performed for communication or for commerce at sea, before the advent of steam, at over 14 knots an hour.

"On the war side we must set the standard of attainment considerably lower. Sail was mainly useful in war in bringing ships within fighting range. When the vessels were once engaged the sails were simply an encumbrance and a peril. Only where forces were unequal and attempts had to be made to evade or to force a fight could advantage in sailing power become important and decisive. Passages were made by fighting ships under sail as good as any that were made by the fastest ships carrying mails—in fact, the 'Mails' were fighting ships. But in the actual fighting operations after the positions had been taken speed did not count. The only speeds which could be safely reckoned on in combats were such as were obtained by war galleys. We know that the galley of the Northmen was an exceedingly well-formed and well-proportioned boat. There is an almost complete actual Viking galley in existence. It is probably a true representative of the boats which carried Rollo and

Plate 1


VICTORIAN EXPANSION
POWERFUL
GOLIATH
UNDAUNTED
HOWE
IRIS
ALEXANDRA
INCONSTANT
HERCULES
WARRIOR
AGAMEMNON
WAR SHIPS AT
THEIR BEST
THE VESSELS AT FULL
LINE WOULD REACH THE


N STEAM SPEED AT SEA
1899
1889
1879
1869
1859
1849
1839
LUCANIA
UMBRIA
BRITANNIC
JAVA
SHANNON
EINSTER
ED STARTING FROM THE CENTRE
SITIONS SHEWN IN ONE MINUTE

his Northmen to Normandy. She is 80 feet long and 16½ feet wide. With a complement of one hundred men her total weight or displacement would have been about 28½ tons. It is impossible to conceive that such boats, or any boats propelled by oars, could have surpassed in speed the Oxford and Cambridge racing boats which compete annually on the Thames. These boats are from 60 to 63 feet long, and they go over the course at the rate of 11½ or 12 statute miles an hour, or 10 knots an hour. We must accept this speed as the highest ever under command as an element in actual fighting at sea before the advent of steam.

"If you will turn to the diagram (Victorian expansion) which has been prepared to show the way in which speeds increased during the reign of Queen Victoria you will see how wonderful the expansion has been. At the commencement of the reign no passages at speeds exceeding 14 knots could be made, however urgent the circumstances. The Queen lived to see with her own eyes a steam vessel running at 34 knots an hour. This speed has been obtained in a vessel designed for war service, and the Queen thus found herself in the remarkable position that whereas all previous maritime communities had found their fighting speeds limited to ten knots an hour, her own people have given her the power of sending her sailors into close action at speeds more than three times as great, and they have accomplished this within sixty years. A Scotsman laid the foundation, an Englishman made the three greatest steps in it, and an Irishman has made the last.

"The diagram is arranged to show a scale of years commencing with the first push out under steam in excess of the immemorial speeds and coming up to date. On a certain scale a line is drawn representing a dis-

tance from the centre line of a sixtieth part of ten knots. On the mercantile side of the diagram there is another line showing fourteen knots. On this same scale the lengths of the ships are drawn, and the space passed over in a given time represents the number of her own lengths which each ship would pass over in that time. The time represented is one minute. The ships at the bottom of the diagram on the right would have passed over about six times their own length in one minute when traveling at 14 knots an hour, and the diagram is made to show this. This is what I have called the supreme power under sail.

"At the date 1837 the 'Great Western' is shown—Brunel's great venture in Atlantic steam navigation. The point she would reach at her best speed in smooth water is put at eleven knots. This was a remarkable performance, for the highest speeds obtained by the mail steamers on the Dover and Calais passage in 1840 was only ten knots. The next above the 'Great Western' is a remarkably fast vessel of the time—the 'Banshee.' She had a displacement not exceeding 280 tons, and as the areas of the blocks are in proportion to the displacements or weights of the ship, she is represented by a thin line. She is said to have reached a speed of 13½ knots in 1848. In 1859 we get a Royal West India Mail steamer, built by Robert Napier, with a record of 14 knots. Almost immediately after came the Irish mail boats, with the very high speed of 17¾ knots in smooth water. The fastest Cunarder of 1865, the 'Java,' is credited by the Cunard Co. with only 14 knots, but here again something must be added to the sea speeds in order to compare with the ships of war on the other side of the diagram, where measured mile speeds are taken. I have therefore shown the measured mile speed of the

'Java' as 15 knots. Then follows the 'Britannic,' designed and built at Belfast for the White Star Line; and then the 'Umbria' and the 'Lucania,' built on the Clyde. This latter ship reaches what I should regard as a measured mile speed of 23½ knots. She has actually run, according to the *Times* ocean records, 562 knots in 24 hours, which is 23.4 knots. The 'Lucania' is 610 feet long. The new 'Oceanic,' building at Belfast for the White Star Line, is to be 704 feet long, and, as I am very glad to see, 68 feet wide. She is nearly five times as large as her predecessor, the 'Oceanic' of 1870.

"These passages have, according to the *Times*, shown the highest average of speed on the Atlantic run during 1898, to have been:—'Lucania,' 21.99 knots; 'Umbria,' 18.59 knots; 'Campania,' 20.96 knots; 'Majestic,' 19.37 knots; 'Etruria,' 19.13 knots; 'Teutonic,' 19.6 knots.

"The fighting ships on the war side are placed in the positions they would occupy at the end of one minute had they started with their stems at the middle line. The battle ships of the early part of the Queen's reign are shown at a speed of ten knots an hour, which is certainly in excess of any speed they could have commanded, but it represents, as has been said, a speed which might possibly have been obtained for war purposes under very favourable circumstances by boats propelled by oars. It is not until 1850 that the steam line-of-battle ship makes its appearance with a speed of 11¼ knots. In 1861 the armoured ship 'Warrior' appears with 14 knots. In 1868 the armoured 'Hercules,' with 14½ knots, and with her the corresponding cruiser 'Inconstant,' with 16½ knots. Then follow, in 1857, the twin-screw armoured ship 'Alexandra,' of 15 knots, and the corresponding twin-

screw cruiser 'Iris,' of 18 knots. In 1884 we have the twin-screw armoured ship 'Howe,' of 16¾ knots, and the corresponding armoured cruiser "Undaunted,' of 18 knots. At the top of the list of increasing speeds appear the ships of the 'Goliath' class of 1897 of 18¾ knots, and the corresponding cruiser class, 'Powerful' and 'Terrible'—22 knots.

"Among the ships of commerce the progress has been steady. It has been effected by improvements in material, in propellers, in speed of machinery, and by greater lengths of ships, following the lead of the White Star liners.

"On the side of the ships of war it was not until 1875 or '76 that the desire arose to have higher speeds than those with which the navy was familiar for fighting purposes. It was ten years later still that sail power was finally abandoned, and the attainment of high speeds under steam became possible. In all the ships shown, up to and including the 'Alexandra,' large sail power was an important feature, first perhaps as a training factor, then as a means of reducing coal consumption, and lastly, as a stand-by in the event of a break down in machinery, or of having empty bunkers.

"If I were asked who set the fashion for higher speeds in vessels of war, a fashion to which so much is now sacrificed, I should say that the Armstrong firm originated it in ships built for weak foreign navies to whom speed would be of great importance. Before this date British Naval officers appear to have said that speeds of fourteen knots could be approached under sail. That, therefore, officers in command of steam ships with auxiliary sail power would use sail often, whereas, if higher steam speeds were given in cruising vessels, sail would fall into disuse, as it had already

done in the French navy. They were already building long and narrow steamers of superior speeds under steam, but with no sail power, while in Great Britain we were building short, protected, well-armed ships, with considerable sail power, but not fast as steam ships. The 'Calliope' is a ship of this latter type with large sail power, but, as we know, with sufficient steam power to enable Captain Kane to steam out to sea in the teeth of the gale at Samoa.

"It was in 1880 that Mr. George Rendel designed for the Armstrong firm some vessels of war, for China, 210 feet long, and of 16 knots speed. Into these he put heavy guns and a large amount of protection by skilful devices which enabled him to avoid the use of armour on the sides of the ship. These he followed up, in 1882, by the design of the 'Esmeralda,' of 18¼ knots. She was 270 feet long. These vessels, and particularly the 'Esmeralda,' did two notable things. They made the fortune of the Armstrong firm; for the 'Esmeralda' type, sometimes with a narrow strip of side armour, but more often with none, is now in high favor in all navies. Secondly, they have led to increase in speed in all ships of war, and to the abandonment of sail power. Steam has been spoiling the sailor in merchant ships for many years, let us see to it or it will do the same in ships of war.

"The cruising ship of war has now reached the dimensions and nearly the speed of the most powerful Atlantic mail steamers. This, in my judgment, is greatly to be regretted. I think it would not have happened if the machinery in the mail steamers had been reasonably protected against gun fire. The splendid Reserved Cruisers, like the 'Teutonic' and the 'Cunarders,' and the rest, are now armed, protected by speed, some of them by twin screws and by good bulk-

13

heads. But their engines still stand high above the sea level. Herein lies their remaining weakness for actual fighting if the duty of protecting commerce against fast hostile cruisers should be entrusted to them. While we have to note that the ship of war has already reached the top speeds of to-day, we must note also that on a somewhat different road still higher speeds are available for war service, and no limit can be assigned to the speeds which may be obtained along this road in future. I have in this connection to call your attention to four short and narrow lines on each side of the diagram, shooting out ahead of all the ships in the minute assigned to them, starting from the middle line. These represent successive steps in the most striking development of steam power which has occurred in the history of steam navigation. They are the vessels of the torpedo-boat type, commencing with the 'Miranda' in 1871, passing on to the 'Gitana,' built for the Baroness Rothschild, on the Lake of Geneva, in 1876; to the 'Ariete,' built for Spain in 1887; and to the 'Turbinia,' built on the Tyne in 1897.

"The 'Lucania' travels over nearly four times her own length in a minute, and the 'Powerful' over rather more than four times her length. The 'Miranda,' which was 50 feet long, went well over thirty times her own length in a minute; and the 'Turbinia' which is 100 feet long, has done somewhat better.

"Up to 1871 it was thought to be impossible to make small steam vessels go as fast as the fastest large ones. In the 'Miranda' we saw this done for the first time. Mr. Thornycroft built this boat of exceeding lightness, and put into her very fast-running engines. She achieved for him a success unequalled in the long history of progress in marine propulsion,

so far as we know it. In this boat 35½ horse-power was developed for every ton weight of the machinery, including boilers and water. The Irish mail boats of 1860, shown just below the 'Miranda' on the right side of the diagram, obtained only seven horse-power per ton. In the 'Gitana' of 1876, Mr. Thornycroft increased this performance to 51½ horses per ton, or 43½ lbs. for each steam horse, including boilers and water. The 'Gitana' and the 'Ariete' were both record breakers. Out of four great steps in speed-making, which will make the last quarter of a century forever illustrious, Mr. Thornycroft must be credited with three, and an electrical engineer, the Hon. Charles Parsons, with the last. They have had fellow-workers who have earned renown in the same field. Mr. A. F. Yarrow on the Thames, and M. Normand at Havre, have each successes in record breaking on the road first entered by Mr. Thornycroft. These little vessels are so light that no appreciable area can be assigned to the blocks representing them.

"Mr. Thornycroft, in his several successes, has given us a new form of boat, a new system of construction, a new form of propeller, and an effective way of generating steam by methods which had been often tried unsuccessfully and abandoned.

"Mr. Parsons has given a new marine steam engine. He has also confirmed, by dearly bought experience, the fact of a serious and only recently recognised limitation in the power of the screw propeller, brought to light first by Mr. Thornycroft in his trials of the 'Daring.' The first public reference to difficulties which might be expected when the propeller was driven at very high speeds was made much earlier, namely, in March, 1888, by Mr. Sydney Barnaby in a discussion at the Institute of Naval Architects. In

1895, in connection with the trials of the 'Daring,' Mr. Thornycroft and Mr. Barnaby, in a joint paper read before the Institute of Civil Engineers in London, gave the propeller conditions under which this difficulty would be met.

"Mr. Parsons first built the 'Turbinia' with one screw propeller, and then found he must put in three shafts and nine propellers in order to meet these difficulties and get full effect out of his high speed engines. He is now building engines of 10,000 and 12,000 horse-power for destroyers of some 320 tons displacement. He says that in applying turbine engines of, say, 30,000 horse-power to a large passenger vessel or war-ship, four screw shafts with two screws on each shaft would probably be necessary in order to get over the propeller limitations in efficiency which have been referred to.

"Before passing from the sheet which gives the records of expansion in speeds we ought to note a few names of men who have most contributed to the wonderful result. First, there is James Watt, with his creation of the steam condenser and the revolution he effected in men's thoughts as to the capacities of the steam engine. Then we have Captain Ericsson, F. P. Smith, B. Woodcroft, Professor Rankine, and John Isaac Thornycroft in the propeller. Isambard Kingdom Brunel, in his 'Great Western,' 'Great Britain,' and 'Great Eastern,' made successive steps in advance in the proportions of ships and in structural arrangements for securing lightness with efficiency. Mr. John Scott Russell, Sir Edward Harland, Mr. Thornycroft, the late Mr. W. Froude, and his son, Mr. R. E. Froude, have all made progress in the improvement of form, and especially Mr. W. Froude as the adviser of the Admiralty in favour of

wide ships with suitably formed ends. In 1875, the 'Iris' and 'Mercury' broke the record for ships of war in speed as the result of his investigations. If we compare the proportions of this ship of 18 knots with those of the 'Isis' of 20 knots, built twenty years afterwards, we shall find that they are the same.

"Speaking of the 'Howe,' a later and very much larger ship, also based upon the investigations made by Mr. Froude in his tank experiments at Torquay, Sir William White says, comparing her with the 'Warrior,' that while the 'Howe' is shorter than the 'Warrior' by 55 feet, is broader by 10 feet, and is heavier by 800 tons, she was as easily driven as the 'Warrior' up to the maximum speed which the 'Warrior' obtained. The 'Howe,' moreover, reached a mean speed of 17 knots against the 14 knots of the 'Warrior.' Comparing the 'Howe' and 'Collingwood' of 1884 with a well formed armoured ship of 1868, the same authority says that the two types of ships are of the same length, but the later ships are nine feet broader than the earlier one. If, he says, the earlier ship had performed as well as the later and broader ships, her speed, with the power she developed, would have been 1¼ knots higher than it was. The later wide ships, he concludes, although a thousand tons heavier than the earlier one, can be driven at the top speed of the earlier ship with only 70 per cent. of her power.

"This great increase in breadth threatened heavy rolling, but it was hoped that the disposition of weights and the use of bilge keels would overcome the rolling tendency introduced by wide beam and great stability. Happily the forecast, justified as it seemed to be by previous experience with bilge keels, was confirmed in all the ships.

"In structural arrangements for securing speed by

lightness of hull we have Mr. Brunel, Mr. Scott Russell, Mr. Thornycroft, and other persons, making remarkable contributions. Of prime importance in lightening the hull and machinery of the ship are improvements in the material of which they are built. In the wooden line of battle-ship 'Goliath,' launched in 1843, the weight of the hull or body of the ship, without masts, guns, or stores of any kind, was rather more than one-half of the completed weight of the ship. Seven-eighths of the weight of the hull was made up of the weight of the timber alone with which it was built. In the iron ship of war, 'Warrior,' the weight of the hull was still one-half of the total weight of the ship exclusive of her armour.

"In the steel ship the weight of the materials comes down from over 50 per cent to 36 per cent of the displacement. This saving is due partly to wise dispositions of material, but mainly to improvements in the material itself—improvements which we owe to Sir Henry Bessemer and Sir William Siemens, but chiefly to the latter. The story concerning the material is modestly told by Mr. James Riley, one of the heroes in it, and now the general manager of the Glasgow Iron and Steel Company, in the *Engineering Magazine* for November and December, 1898. Among the striking things which he tells us is that while in 1877, twenty years after Bessemer steel was first introduced, not a single ship was building of steel under Lloyd's survey, over a million tons were building under that survey in 1889, as a consequence of the improvements made by Sir William Siemens and of the start made by the Admiralty in 1875. These improvements in material, resulting in the production and general adoption of mild steel, have affected every

part of the ship, of her engines, her boilers, and her armament. Among the improvements in steam machinery, tending to increases in speed, have been increases in speed of revolution; the economical use of steam by which heat has been made to do more work while it was under control; the introduction of forced draught to the furnaces; and the improvements in water-tube boilers. In the more important of these the "Clyde" has been notably distinguished, as it has also been in the successive steps taken by the able directors of the Cunard Company. I have not mentioned improvements in armour as tending to increase speeds in ships carrying it, because, while armour has certainly gone ahead of projectiles in respect of quality, and has met, in a remarkable manner, the successive steps in the development of quick-firing guns of small calibre, we are still left in doubt as to how the best thin armour will behave under smashing blows from large projectiles."

The following table compiled from Lloyd's Register shows the sizes, speeds and nationalities of all the fast steamships in the world at the close of the nineteenth century.

LIST OF STEAM SHIPS IN THE WORLD IN 1900 OF OVER 3000 TONS GROSS TONNAGE AND OF SPEEDS OF 14 KNOTS AND UPWARDS. THEIR SPEED, TONNAGE AND NATIONALITY.

Twenty Knots and Above.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Campania"	12950	Br.	Cunard.
"Etruria"	8120	Br.	Cunard.*
"Lucania"	12952	Br.	Cunard.
"Majestic"	9965	Br.	White Star.*
"Oceanic"	17274	Br.	White Star.
"Teutonic"	9984	Br.	White Star.*
"Umbria"	8128	Br.	Cunard.*
"La Lorraine"	11200	Fr.	
"La Savoie"	11200	Fr.	
"Deutschland"	16500	Germ.	
"Kaiser Wilhelm II."	20000	Germ.	
"Kaiser Wilhelm der Grosse"	14349	Germ.	
"Kaiserin Maria Theresia"	8278	Germ.	
"Kronprinz Wilhelm"	15000	Germ.	
"Moskva"	7267	Russ.	
"New York"	10674	U. S.	Intern. Nav. Co.
"Philadelphia"	10669	U. S.	Intern. Nav. Co.
"St. Louis"	11629	U. S.	Intern. Nav. Co.
"St. Paul"	11629	U. S.	Intern. Nav. Co.

Nineteen Knots and Under Twenty Knots.

"L'Aquitaine"	8810	Fr.	
"La Touraine"	9047	Fr.	
"Columbia"	7241	Germ.	
"Fürst Bismarck"	8430	Germ.	
"Kherson"	6438	Russ.	
"Orel"	4880	Russ.	
"Petersburg"	5336	Russ.	
"Saratoff"	5309	Russ.	

*See page 191.

Eighteen Knots and Under Nineteen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Caledonia"	7558	Br. ...	P. & O. Co.
"Auguste Victoria".....	8479	Germ..	
"Lahn"................	5351	Germ..	
"Arabia"...............	7903	Br. ...	P. & O. Co.
"Australia"	6901	Br. ...	P. & O. Co.
"China"................	7912	Br. ...	P. & O. Co.
"Egypt"................	7912	Br. ...	P. & O. Co.
"Himalaya"............	6898	Br. ...	P. & O. Co.
"India".................	7911	Br. ...	P. & O. Co.
"Omrah"	8291	Br. ...	Orient S. N. Co.
"Ophir"................	6910	Br. ...	Orient S. N. Co.
"Ormuz"...............	6387	Br. ...	Orient S. N. Co.
"Ortona".	7945	Br. ...	Pacific S. N. Co.
"Persia"	7900	Br. ...	P. & O. S. N. Co.
"Saale"................	5267	Germ..	
"Trave"................	5261	Germ..	

Seventeen Knots and Under Eighteen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Briton"	10248	Br. ...	D. Currie & Co.
"Carisbrook Castle"	7626	Br. ...	D. Currie & Co.
"City of Rome".........	8453	Br. ...	Barrow S. S. Co.
"Kildonan Castle"......	9652	Br. ...	Union Castle Co.
"Kinfanus Castle"......	9664	Br. ...	Union Castle Co.
"Norman"..............	7537	Br. ...	D. Currie & Co.
"Saxon"................	12570	Br. ...	Union Castle Co.
"Scot"..................	7815	Br. ...	D. Currie & Co.
"Armand Béhic"	6635	Fr.....	
"Australien"	6428	Fr.....	
"La Bretagne"	7112	Fr.....	
"La Champagne".......	7087	Fr.....	
"La Gascogne".........	7395	Fr.....	
"Polynésien"...........	6506	Fr.....	
"Ville de la Ciotat".....	6431	Fr.....	
"Aller".................	5217	Germ..	
"Arcadia"..............	6603	Br. ...	P. & O. Co.
"Atrato"...............	5140	Br. ...	Royal Mail.
"Aurania"..............	7269	Br. ...	Cunard.
"Austral"	5524	Br. ...	Orient S. N. Co.

Seventeen Knots and Under Eighteen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Britannia"	6525	Br.	P. & O. Co.
"Clyde"	5645	Br.	Royal Mail.
"Danube"	5946	Br.	Royal Mail.
"Germanic"	5071	Br.	White Star.
"Magdalena"	5140	Br.	Royal Mail.
"Nile"	5946	Br.	Royal Mail.
"Oceana"	6603	Br.	P. & O. Co.
"Oriental"	5284	Br.	P. & O. Co.
"Peninsular"	5287	Br.	P. & O. Co.
"Thames"	5645	Br.	Royal Mail.
"Victoria"	6527	Br.	P. & O. Co.
"Annam"	6344	Fr.	
"Ernest Simons"	4562	Fr.	
"Indus"	6357	Fr.	
"La Navarre"	6648	Fr.	
"Tonkin"	6364	Fr.	
"Ems"	4912	Germ.	
"Margherita"	3577	Italian	
"America Maru"	6210	Jap.	
"Hong Kong Maru"	6064	Jap.	
"Nippon Maru"	6048	Jap.	
"China"	5060	U. S.	Pacific Mail.
"Havana"	5667	U. S.	N. Y. & Cuba Mail.
"Mexico"	5667	U. S.	N. Y. & Cuba Mail.
"Priscilla" (Paddle)	5292	U. S.	Old Colony S. Co.

Sixteen Knots and Under Seventeen Knots.

"Empress of China"	5905	Br.	Canadian Pacific.
"Empress of India"	5905	Br.	Canadian Pacific.
"Empress of Japan"	5905	Br.	Canadian Pacific.
"Orizaba"	6298	Br.	Pacific S. N. Co.
"Orotava"	5857	Br.	Pacific S. N. Co.
"Oroza"	6297	Br.	Pacific S. N. Co.
"Oroya"	5857	Br.	Pacific S. N. Co.
"Servia"	7392	Br.	Cunard.
"Brésil"	5876	Fr.	
"Chili"	6375	Fr.	
"Cordillière"	6379	Fr.	

Sixteen Knots and Under Seventeen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"La Normandie"........	6283	Fr.....	
"La Plata".............	5807	Fr.....	
"Nord America"........	4826	Italian	
"Puritan" (paddle)......	4593	U. S...	Old Colony.
"Assaye"...............	7376	Br. ...	P. & O. S. Co.
"Bavarian".............	10376	Br. ...	H. & A. Allan.
"Britannic"............	5004	Br. ...	White Star.
"Don"..................	4028	Br. ...	Royal Mail.
"Dunottar Castle"......	5465	Br. ...	D. Currie & Co.
"Dunvegan Castle"	5958	Br. ...	D. Currie & Co.
"Ivernia"..............	13800	Br. ...	Cunard.
"Oravia"...............	5321	Br. ...	Pacific S. N. Co.
"Orient"...............	5631	Br. ...	Orient S. N. Co.
"Orinoco"..............	4434	Br. ...	Royal Mail.
"Para".................	4028	Br. ...	Royal Mail.
"Plassy"...............	7380	Br. ...	P. & O. Co.
"Saxonia"..............	13800	Br. ...	Cunard.
"Sobraon"..............	7382	Br. ...	P. & O. Co.
"Tagus"................	5545	Br. ...	Royal Mail.
"Tantallon Castle"......	5636	Br. ...	D. Currie & Co.
"Trent"................	5573	Br. ...	Royal Mail.
"Tunisian".............	10576	Br. . .	H. & A. Allan.
"Bohemia".............	4318	Austro-Hung.	
"Semiramis"...........	4023	Austro-Hung.	
"Hamburg"............	10600	Germ..	
"Kaiser Wilhelm II." ...	6661	Germ..	
"Kiautschou"...........	11100	Germ..	
"Werra"...............	5012	Germ..	
"Orione"...............	4161	Italian	
"Perseo"...............	4158	Italian	
"Sirio"................	4141	Italian	
"Alfonso XIII.".........	5125	Span..	
"Reina Maria Cristina"..	5161	Span..	
"Governor Dingley"....	3826	U. S...	Portland S. S. Co.
"Hamilton".............	3128	U. S...	Old Dom. S. S. Co.
"Jefferson".............	3127	U. S...	Old Dom. S. S. Co.
"Kansas City"..........	3679	U. S...	Savannah Line.
"Plymouth (paddle).....	3779	U. S...	Old Colony S. Co.
"Princess Anne"........	3079	U. S...	Old Dom. S. Co.

Fifteen Knots and Under Sixteen Knots.

Name	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Moana"	3915	Br.	N. S. S. Co. New Zealand.
"Orissa."	5317	Br.	Pacific S. N. Co.
"Oropesa"	5303	Br.	Pacific S. N. Co.
"Rome"	5545	Br.	P. & O. Co.
"Cleopatra"	4082	Austro-Hung.	
"Habsburg"	4016	Austro-Hung.	
"Barbarossa"	10769	Germ.	
"Bremen"	10525	Germ.	
"Friedrich der Grosse"	10568	Germ.	
"Grosser Kurfürst"	13182	Germ.	
"König Albert"	10613	Germ.	
"Königin Louise"	10566	Germ.	
"Prinzess Irene"	11000	Germ.	
"Savoia"	5279	Italian	
"El Cid"	4608	U. S.	S. Pacific Co.
"El Norte"	4605	U. S.	S. Pacific Co.
"El Rio"	4604	U. S.	S. Pacific Co.
"El Sud	4572	U. S.	S. Pacific Co.
"Pilgrim" (Paddle)	3484	U. S.	Old Colony S. Co.
"Carthage"	5198	Br.	P. & O. Co.
"Chile"	3225	Br.	Pacific S. N. Co.
"Clyde"	4099	Br.	P. & O. Co.
"Colombia"	3335	Br.	Pacific S. N. Co.
"Coptic"	4356	Br.	White Star.
"Cuzco"	3898	Br.	Orient S. S. Co.
"Cymric"	12647	Br.	White Star.
"Doric"	4676	Br.	White Star.
"Elbe"	3093	Br.	Royal Mail.
"Furnessia"	5495	Br.	Henderson Bros.
"Gothic"	7755	Br.	White Star.
"Guatemala"	3227	Br.	Pacific S. N. Co.
"Hawarden Castle"	4380	Br.	D. Currie & Co.
"Hyson"	6608	Br.	China Mutual S. N. Co.
"Iberia"	4689	Br.	Pacific S. N. Co.
"Kintuck"	4447	Br.	China Mutual S. N. Co.

Fifteen Knots and Under Sixteen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Liguria"...............	4677	Br. ...	Pacific S. N. Co.
"Mesaba"...............	6833	Br. ...	Atlantic Transport Co.
"Miowera".............	3393	Br. ...	New Zealand S. Co.
"Mokoia"...............	3502	Br. ...	Union S. S. Co., New Zealand.
"Moor".................	4464	Br. ...	Union Castle Mail.
"Moyune"..............	4646	Br. ...	China Mutual S. N. [Co.
"Norham Castle".......	4392	Br. ...	D. Currie & Co.
"Orcana"...............	4803	Br. ...	Pacific S. N. Co.
"Orellana".............	4821	Br. ...	Pacific S. N. Co.
"Pak Ling".............	4447	Br. ...	China Mutual S. N. [Co.
"Parisian".............	5395	Br. ...	H. & A. Allan.
"Peru".................	3225	Br. ...	Pacific S. N. Co.
"Roslin Castle"........	4487	Br. ...	D. Currie & Co.
"Shannon"..............	4362	Br. ...	P. & O. Co.
"Teenkai"..............	4462	Br. ...	China Mutual S. N. Co.
"Warrimoo"............	3326	Br. ...	New Zealand Shipping Co.
"Yang Tsze"...........	6457	Br....	China Mutual S. N. Co.
"Friesland"............	6409	Belg'n	
"Versailles"...........	4336	Fr....	
"Prinz Heinrich".......	6263	Germ..	
"Prinz Regent Luitpold"..................	6288	Germ..	
"Prinzessin Victoria Louise"...............	4600	Germ..	
"Potsdam"..............	12522	Holl'd.	
"Rotterdam"...........	8139	Holl'd.	
"Statendam"...........	10491	Holl'd.	
"Futami Maru".........	3841	Jap....	
"Kasuga Maru".........	3820	Jap....	
"Taichi Maru"..........	3358	Jap....	
"Tainan Maru".........	3450	Jap....	
"Yawata Maru".........	3818	Jap....	
"Leon XIII"............	4686	Span'h	
"P. de Satrustegui".....	4710	Span'h	
"Mariposa".............	3158	U. S...	Oceanic S. Co.

Fourteen Knots and Under Fifteen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Athenian"	3882	Br.	Canadian Pacific.
"Californian"	4244	Br.	H. & A. Allan.
"Derbyshire"	6636	Br.	Bibby Bros.
"Kensington"	8669	Br.	Intern. Nav. Co.
"Massilia"	5026	Br.	P. & O. Co.
"Monowai"	3433	Br.	Union S. S. Co. of New Zealand.
"Rowanmore"	9350	Br.	W. Johnston & Co.
"Southern Cross"	5050	Br.	Houlder Bros.
"Southwark"	8607	Br.	Intern. Nav. Co.
"Staffordshire"	6005	Br.	Bibby Bros.
"Winifredian"	10405	Br.	F. Leyland & Co.
"Westernland"	5708	Belg'n	
"Portugal"	5549	Fr.	
"Bayern"	5034	Germ.	
"Preussen"	5295	Germ.	
"Sachsen"	5026	Germ.	
"Maasdam"	3900	Hol'nd	
"Duca di Galliera"	4304	Italian	
"Duchessa di Genova"	4304	Italian	
"Monte Video"	5297	Span.	
"Segurança"	4033	U. S.	N. Y. & Cuba Mail.
"Vigilançia"	4115	U. S.	N. Y. & Cuba Mail.
"Armenian"	8825	Br.	F. Leyland & Co.
"Ballarat"	4890	Br.	P. & O. Co.
"Beacon Grange"	4042	Br.	Houlder Bros.
"Bengal"	4656	Br.	P. & O. Co.
"Carinthia"	5598	Br.	Cunard.
"Cestrian"	8823	Br.	F. Leyland & Co.
"Cheshire"	5708	Br.	Bibby Bros.
"Ching Wo"	3883	Br.	China Mutual S. N. Co.
"Chusan"	4636	Br.	P. & O. Co.
"City of Vienna"	4672	Br.	C. Smith & Sons.
"Corcovado"	4568	Br.	Pacific S. N. Co.
"Coromandel"	4652	Br.	P. & O. Co.
"Gaelic"	4206	Br.	White Star.
"Glenogle"	3750	Br.	McGregor, Gow & Co.
"Idaho"	6308	Br.	T. Wilson, Son & Co.

Fourteen Knots and Under Fifteen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Ionic"	4748	Br. ...	White Star.
"Kaisow"	3921	Br. ...	China Mutual S. N.
"Lancashire"	4244	Br. ...	Bibby Bros. [Co.
"Laurentian"	4522	Br. ...	H. & A. Allan.
"Malta"	6064	Br. ...	P. & O. Co.
"Moravian"	4573	Br. ...	G. Thompson & Co.
"Nubia"	5914	Br. ...	P. & O. Co.
"Oopack"	3883	Br. ...	China Mutual S. N.
"Parramatta"	4886	Br. ..	P. & O. Co. [Co.
"Royston Grange"	4018	Br. ...	Houlder Bros.
"Salamis"	4508	Br. ...	G. Thompson & Co.
"Shropshire"	5721	Br. ...	Bibby Bros.
"Simla"	5884	Br. ...	P. & O. Co.
"Sorata"	4581	Br. ...	Pacific S. N. Co.
"Sutlej"	4164	Br. ...	P. & O. Co.
"Sylvania"	5598	Br. ...	Cunard.
"Templemore"	6344	Br. ...	W. Johnston & Co.
"Thames"	4258	Br. ...	P. & O. Co.
"Uestermore"	6411	Br. ...	W. Johnston & Co.
"Valetta"	5048	Br. ...	P. & O. Co.
"Vedamore"	6330	Br. ...	W. Johnston & Co.
"Victorian"	8825	Br.....	F. Leyland & Co.
"Yorkshire"	4261	Br.....	Bibby Bros.
"Imperator"	4213	Austro-Hung..	
"Imperatrix"	4194	Austro-Hung..	
"Lafayette"	3394	Fr.....	
"Koning Willem I."	4272	Hol'nd	
"Koning Willem II."	4290	"	
"Koning Willem III."	4300	"	
"Koningin Wilhelmina"	4249	"	
"Kamakura Maru"	6123	Jap....	
"Alvares Cabral"	3199	Portuguese	
"Loanda"	3199	"	
"Malange"	3544	"	
"Rei dè Portugal	3198	"	
"Buenos Aires"	5311	Span..	
"Cataluña"	3785	Span..	

Fourteen Knots and Under Fifteen Knots.

Name.	Gross tonnage.	Nationality.	Owners of British or U. S. ships.
"Montserrat"...........	4076	Span..	
"City of Para"..........	3532	U. S...	Pac. Mail S. S. Co.
"City of Peking".......	5080	U. S...	Pac. Mail S. S. Co.
"City of Rio de Janeiro"	3548	U. S...	Pac. Mail S. S. Co.
"Concho"..............	3724	U. S...	C. H. Mallory & Co.
"El Mar"...............	3531	U. S...	South. Pacific Co..
"Orizaba"..............	3497	U. S...	N. Y. & Cuba Mail.
"Peru".................	3528	U. S...	Pacific Mail.
"Umatilla".............	3070	U. S...	Pac. Coast S. S. Co.
"Victoria"..............	3502	U. S...	N. American Mail.
"Walla Walla".........	3070	U. S...	Pac. Coast S. S. Co.
"Yucatan"..............	3525	U. S...	N. Y. & Cuba Mail.

CHAPTER XII.

WATERTIGHT SUBDIVISION.

Reference has already been made, in the chapter on the Sailor and his Home, to the action of the Council of Naval Architects in 1867, five years after the Board of Trade had induced the legislature to set owners and builders free as to what bulkheads there should be in passenger and in other ships.

At that date (1867), the country had been startled by the peculiar circumstances attending the loss of the S. S. London and it was this loss which led to the action of the Institution. After the deliberations were concluded a deputation of the Council, of which the author was one, had an interview with the President of the Board of Trade in the hope that the matters brought to his notice and particularly that of water-tight bulkheads might influence legislation.

But the Board of Trade feared to impose fetters, and did nothing. Then the Admiralty made enquiries, offered suggestions, and as will be seen by the evidence given was successful in influencing owners to put in additional bulkheads and to make those effective which were in.

Official returns which credited the ship with a certain number of bulkheads took no notice of the fact that they were often useless: in some cases, because holes had been cut in them for convenience; and in others that they finished at a deck quite near

the water-line. Owners were found to be willing to remedy these defects. Sometimes by a very small expenditure ships which had flagrantly failed to satisfy the condition of 1867 were made to do so.

In 1883 Mr. James Dunn, an Admiralty officer, read a paper at the Institution of Naval Architects on this subject. He said that it had been his duty for several years to give special attention to this question for merchant ships and he had had the opportunity of fully considering it in consultation with the shipowners. In the early days of iron ships he said they found the ships furnished with a collision bulkhead, placed a few feet from the bow, and this bulkhead saved many ships. At the stern also was a bulkhead, or a box, through which the shaft passed water-tight into the tunnel or passage; and enclosing the machinery and coal space were two iron bulkheads required by Act of Parliament, thus leaving two spaces, the fore and after holds, for freight carrying. At that time such an arrangement practically divided the ship into three equal lengths, which was thought satisfactory. By and by ships were lengthened and the machinery space shortened so that the cargo holds became each more than twice the length of the midship compartment. Then in 1862, that section of the Merchant Shipping Act which gave the Board of Trade surveyors power to require water-tight partitions to be fitted was repealed under the advice of the Board of Trade itself and without any discussion whatever in parliament.

The partitioning off of the machinery space was a necessity so obvious that it was continued, and in this position the Admiralty found the question when, in 1875, Mr. Ward Hunt desired to have the question in-

vestigated. After careful enquiry, extending over many months, the serious conclusion arrived at was that there were not thirty British sea-going ships in existence complying with the requirement of the Institution of Naval Architects in order to secure a minimum measure of safety.

There were found to be more than 4,000 steamships, of 100 tons and upwards, which would sink if any compartment between the collision and the stuffing box bulkheads were laid open to the sea in smooth water.

At this date, and subsequently, the Secretary of the Board of Trade was rejoicing that the law had been repealed in 1862 which compulsorily required two bulkheads. On the repeal of that law, said he, in 1887, there came to be four, five and six bulkheads directly. That shows, he said, that if you want any improvement to go on you must not tie any industry down by hard and fast statutory laws, however good they may appear at the moment. If he had been asked whether these bulkheads rose far enough above the water-line to be of any value for preventing or delaying foundering he must have replied either that they did not, or that he had no information in that respect. The fact is that these bulkheads were put in to stiffen the structure of the ship and not as useful water-tight partitions.

So far as Lloyds' surveyors were concerned they were demanding that iron steam vessels should have one bulkhead at a reasonable distance from each end of the vessel in addition to the engine room bulkheads. These bulkheads were to extend to the upper deck, in vessels having one or two decks, and, to the tonnage deck, or deck next below the upper deck, in

three-deck vessels. Sailing vessels were required to have a collision bulkhead only, although many of these sailing ships carried passengers.

The ships referred to by Mr. Dunn,—the more than 4,000 ships of 100 tons and upwards which would have sunk had any compartment between the collision and stuffing-box bulkheads been thrown open to the sea in smooth water,—these were all satisfactory to the Board of Trade of that date.

The Board of Trade authorities made no sign, but Lloyd's Committee took heart of grace in 1882 and decided that steam vessels to be classed must, if they were 280 feet long, have an additional water-tight bulkhead in the fore hold, and vessels 330 feet long an additional bulkhead in the fore and after holds. These bulkheads except in awning decked vessels were to extend to the upper deck. They required also that in their one, two, and three-decked ships the bulkheads enclosing the machinery space should be carried watertight to the upper deck.*

*The rules of Lloyd's Surveyors now stand, (1900) as follows:—

1. Screw steamers are to have a water-tight bulkhead at each end of the engine and boiler space. In addition a water-tight collision bulkhead is to be fitted at not less than one-twentieth of the vessel's length abaft the stem at the lower deck, and a water-tight bulkhead is also to be fitted at a reasonable distance from the after end of the vessel. In all cases the foremost or collision bulkhead is to extend from the floor plates to the upper, spar, or awning deck, and its water-tightness is to be tested by filling the peak with water to the height of the load line.

2. In steamers 280 feet and under 330 feet in length, an additional water-tight bulkhead is to be fitted in the main hold about midway between the collision and boiler room bulkheads. In steamers 330 feet and under 400 feet in length, an additional water-tight bulkhead is to be fitted in the after hold; in steamers 400 feet and under 470 feet in length, seven water-tight bulkheads are to be fitted; in steamers 470 feet and under 540 feet in length, eight water-tight bulk-

Referring to these rules Mr. Dunn remarked that it was to be hoped that spar-deck and awning-deck steamers would some day be similarly well treated.

"We shall all hope, too," he said, "that the divisional bulkheads shall be fitted in all classes, and that they shall not, as they may now, stop at the deck which is awash, but that they shall be carried to a deck well above the load water-line."

Mr. Dunn gives the case of a ship illustrated by Fig. I.—and there are many such ships, he said, now afloat—in which a good number, are provided and distributed as shown, but three of which, it will be seen, are stopped at the deck which is awash.

"The bottom gets damaged and springs a leak, say in No. 1. hold, or in No. 2 hold, or in both; and how many such cases have we known where the water enters, and gains on the pumps, and slowly, but surely, rises to the top of the dwarf bulkhead, causing the ship to trim as indicated in Fig. 2. The water is then free to flow over the top of the bulkhead and pour into the next hold, the effect of which is inevitably to send her head-first to the bottom.

"Now we assert that such a ship would keep afloat with the water in No. 1 and in No. 2 hold, provided it is confined by the bounding bulkheads being carried a few feet higher than the natural level. What this natural level is, and to what height the bulkhead

heads are to be fitted, and in steamers 540 feet and under 600 feet in length, nine water-tight bulkheads are to be fitted. These bulkheads are to extend to the height of the upper deck in vessels with one, two, or three decks, to the spar deck in spar-deck vessels, and to the main deck in awning or shelter deck vessels. In awning- or shelter-deck vessels, or vessels with a continuous superstructure, a deep web frame or partial bulkhead is to be fitted on each side in the 'tween decks, over each of the water-tight bulkheads which extend only to the main deck.

FIG. I.

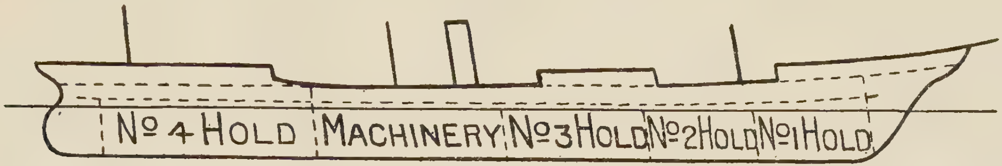
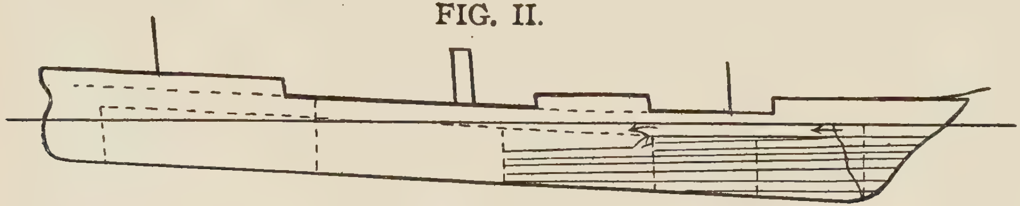


FIG. II.



Water-tight Subdivision—Plate 1.

should be carried, are points readily determined by the naval architect.

"But if they are not carried up, but are left as shown,—and in too many cases they are left so—then we say they had better not be in the ship at all, as they will contribute to her loss by keeping the water at one end of the ship, and carrying her bows under; whereas, if they are not fitted, the same volume of water entering as is indicated in the preceding diagram, and not being confined to one end, will distribute itself through the ship all fore and aft, in which case the trim is preserved, she will still float. And, although the freeboard is reduced, she will still be seaworthy; the fires may be kept burning and the machinery going sufficiently long to bridge over the space dividing life from untimely death.

"We will now take another view, and consider two cases, in one of which the bulkheads were well placed and cared for, and proved that under such conditions they may be of greatest value; the other case is in all respects a contrast. In the first case they were placed in the positions and carried to the height indicated in Fig. III. A steamer of nearly 5,000 tons ran into this ship in a fog, struck her abreast of No. 3 bulkhead, opening up two compartments to the sea; but, fortunately, the bulkheads had been carried to a reasonable height, and the water could not get beyond them; they stood the test, she did not sink, but she kept afloat at the trim shown in Fig. IV. and in this condition steamed 300 miles safely into port.

"The next case is one where we have the same number and a similar disposition of bulkheads as in the previous case; but, unfortunately, some of them are rendered valueless by being stopped at or about the water-line, as indicated in Fig. V. This sketch repre-

FIG. III.

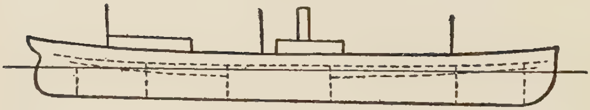


FIG. IV.

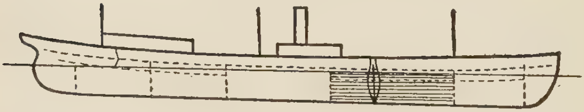


FIG. V.

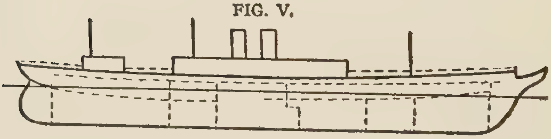
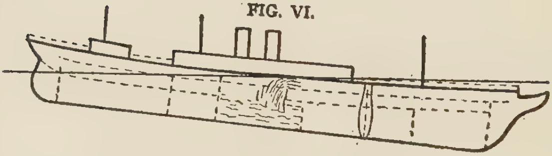


FIG. VI.



Water-tight Subdivision—Plate 2.

sents a large number of first-class steamers now afloat, and should such an accident happen to any of them as has just been described, they would certainly not have the good fortune to complete their journey, as in the last case; but the water, not being confined to the two holds numbered 2 and 3, as it was in the previous case—which is an actual one—will pour over the top of the dwarf bulkhead into the foremost hold, and the ship will soon get into the position indicated in Fig. VI. Water will then be reported to be making in the engine-room, if indeed she should not disappear before then.

"With the sanction of the Admiralty, two fair-sized models have been made to represent the merchant steamer of a very acceptable type, judging from the large number built and building. In one of these models are placed the bulkheads according to a common practice; i. e., with two bulkheads enclosing the machinery space and a divisional bulkhead in the fore-hold. In the other the bulkheads are arranged so as to represent a ship entitled to admission to what is known as the Admiralty List; i. e., with four bulkheads beside those at the bow and stern; viz. two enclosing the machinery space, one divisional bulkhead in the fore-hold, and a corresponding one in the after-hold, all of which are carried to the upper deck.

"The models are loaded with weighted wood blocks, the blocks being of a bulk to represent the cargo in a passenger ship floating at an ordinary load draught with each compartment below the upper 'tween-decks appropriated to cargo, having one-half of its space occupied—a condition ordinarily assumed at the Admiralty when determining whether a ship is qualified for the Admiralty List—and they fairly represent such a ship as regards their measure of stability.

"A hole is made through the bottom plating, to represent an actual hole, about one square foot in area and eight feet below the water surface in each compartment, and a plug is placed in it, so that by removing a plug any part of the model may be laid open to the water.

"The first, or the badly bulkheaded model, very soon disappears after the withdrawal of any one of the plugs, because the water rushing in soon rises to the level of the water outside and is then, or before then, free to flow over the top of the dwarf bulkhead into the adjoining hold.

"But if the corresponding hole in the good model is opened up, the water soon gets in and finds its level, but it is then confined between the bulkheads, and the model remains afloat."

Mr. Dunn rested his hopes of better subdivision in the future on the action of the Committee of Lloyd's Register. The Lloyd's Surveyors are undoubtedly the most competent corporation of shipbuilders connected with the Mercantile Marine in the world, and their public spirit is beyond question. But it must be remembered that they are under the orders of a Committee of Shipowners, and that this Committee cannot compel owners to register in their books and submit to their rules. There are rival registries competing with them. Their long submission to a condition of things, such as has been described, is entirely due to the necessity which lies upon them to follow public opinion. It is not their business to inform it, nor to go in advance of it. Only a government department could have done that, and the fatal action of the Board of Trade in 1862 was a practical abdication of its duties. If control had been maintained over bulkhead division in British ships it would

have been easy to take care that foreign ships, not properly divided, should not embark passengers in British ports. The indisposition of the Board of Trade to interfere still continues, evidently with the concurrence of shipowners and underwriters.

But there is disquiet in the minds of all those who interest themselves in the security of the lives of passengers, or of seamen, at sea. Whenever any question arises out of a great disaster in a passenger ship, as to how life-saving appliances may be enlarged and improved, those who set themselves to enquire discover that the only life-saving appliance much worth considering is the water-tight bulkhead.

In this way it happened that a bulkhead committee was appointed in 1890 under the presidency of Sir Michael Hicks-Beach.

It had been preceded by a committee on life-saving gear in 1887. A writer in the *Times*, April 3, 1893, writing evidently with a full knowledge of the subject, gives the following account of the action of the committee 1887-1890.

"In 1887, a select committee was appointed by the House of Commons to enquire into the "existing laws and regulations regarding boats, life-buoys, and other life-saving gear required to be carried by British Merchant ships. Lord Charles Beresford was chairman, and it was a strong committee containing many shipowners. Their report and evidence have been published as a Blue-Book (No. 249 of 1887). They made two recommendations deserving notice. First, That an advisory committee of experts—representatives of shipowners, shipbuilders, officers and seamen, and technical societies—should be appointed by the Board of Trade and that this committee should frame rules for the future equipment of various classes of ships

with boats and life-saving appliances. Second, they went beyond the letter of their reference, and recorded the opinion—'That the proper placing of bulkheads, so as to enable a ship to keep afloat for some length of time after an accident has occurred, is most important for saving life at sea and a thing upon which the full efficiency of life-saving appliances largely depends.'

"The Board of Trade embodied the first recommendation in the Merchant Shipping (Life-saving Appliances) Act of 1888. Under it an advisory committee was constituted, Mr. Thomas Ismay, of the White Star Line, being chairman, and Mr. Anderson, of the Orient Line, vice-chairman. This committee reported in April, 1889, proposing large additions to equipments of boats, etc., and evoking considerable opposition to their scheme from shipowners. In June, 1890, the Board of Trade issued definite rules, based on the recommendations of the committee, with a notice that they would come into effect in November, 1890. So one stage of the business ended.

"Another, and perhaps more important, point had been raised, however, by the advisory committee, who, like their predecessors on Lord Charles Beresford's committee, were driven beyond their strict instructions by the conviction that life-saving appliances were best carried by a ship difficult to sink. They said:—'We think it our duty further to express our sense of the importance of the question (of efficient subdivision) and to recommend that it should be investigated by a committee of duly qualified persons.' When Sir Michael Hicks-Beach read this passage he must have felt that, like King Charles' head in Mr. Dick's memorial, bulkheads were bound to appear in every investigation of life-saving appliances. In brief,

it was impossible for him to avoid the conclusion that experts thought such appliances of little worth as compared with efficient water-tight subdivision. Incidentally it appeared also that Mr. Ismay's committee thought safety for high-class passenger steamers to require such subdivision as would permit any two compartments to be simultaneously thrown open to the sea without involving the sinking of the ships.

"Action was unavoidable. The President of the Board of Trade, before issuing his new rules for boats and life-saving gear, had appointed the bulkhead committee, and framed their instructions in the following terms:—

'To consider and report upon the following matters, viz.:—

1. 'As to the manner in which ships shall be subdivided, so that they may float in moderate weather with any two compartments in free connexion with the sea; and what rule there should be as to the proportion of freeboard of the water-tight deck next above it, to which such bulkheads are attached, as shall be sufficient to enable the ship so to float.

2. 'As to the description of ship to which such should apply in regard to size, or what difference, if any, as between paddle or screw steamers, or sailing ships, or as to ocean voyagers, or cross-channel steamers.

3. 'Upon the construction and fitting of water-tight bulkheads, with a view to their being able to sustain the necessary strain, particularly when the ship is rising and falling in a sea-way, without shoring or other adventitious aid, should it so happen that two adjoining compartments are in free communication with the sea, regard being given to the support of any 'tween-decks abutting thereto.

4. 'In what manner the surveyors of the Board of Trade can best determine the sufficiency of such bulkheads.

5. 'Under what restrictions may passage ways be permitted through bulkheads, as closable by portable plates, or so-called water-tight doors, self-acting or otherwise; and what precautions are necessary as to openings in longitudinal bulkheads to enable the water to pass freely or under control from one side to the other, in case of the ship showing signs of instability, as might readily be the case should she be struck on a transverse bulkhead, and two compartments, both on one side, be in free communication with the sea.

6. 'Whether a transverse compartment, divided into two by longitudinal bulkhead, should be treated as one or two compartments.

7. 'What particulars, drawings, and calculations should be furnished by the owners of ships to the Board of Trade when they desire to take advantage of the following paragraph in the rules made under the Merchant Shipping (Life Saving Appliances) Act, 1888, (51 and 52 Vict., cap. 24):—

WATERTIGHT COMPARTMENTS.

" 'When ships are divided into efficient water-tight compartments so that with any two of them in free communication with the sea the ship will remain afloat in moderate weather, they shall only be required to carry additional boats or life-rafts of one-half the capacity required by paragraph (f) class 1., Division A. of these rules.'

8. 'Whether independently of the precise requirements of the foregoing paragraph, the committee have

any recommendations to make with reference to bulkheads which would, in their opinion, contribute to the safety of life at sea.'

"The committee nominated to deal with these matters was comparatively a small one, but strong and representative in character. Naturally prominence had to be given to ship-builders, since the inquiry was so largely technical. On the other hand the interests of ship-owners were involved in the inquiry. Happily many gentlemen are both ship-builders and ship-owners; and from their ranks the committee was largely drawn. Sir Edward Harland, of Belfast, was widely known as the builder of some of the finest passenger steamers afloat, as well as vessels of all classes. Mr. Laing, of Sunderland, and Mr. Royden, of Liverpool, not merely represented important shipping centres, but were eminent in ship-building and ship-owning. Mr. Anderson, of London, who had served on the former committee, was experienced in the working and management of an enormous business, including steamers and sailing ships. To these were added a representative marine engineer, the late Mr. Kirk, of Glasgow, and a naval architect of repute, the late Professor Jenkins, of Glasgow University, whose death brought to an untimely close a career of the highest promise. To these appointments no exception could possibly be taken; but it was a matter of surprise, when the committee was announced, that it contained no representative of Lloyd's Register of Shipping, or of the Constructive Department in the Admiralty, since in both directions valuable assistance might have been obtained.

"The questions raised in paragraphs 1, 2, and 8 of the foregoing reference are clearly of the greatest importance, amounting to a demand for reconsidera-

tion of the whole subject of water-tight subdivision in existing merchant ships. The remaining paragraphs deal with matters of considerable interest, but not of primary importance, and largely of a technical character. Leaving these latter questions for a time, attention will first be directed to the spacing of bulkheads, which has been shown above to be the crucial matter, especially in cargo vessels.

"The committee deal at great length with the problem of the '*maximum* length of the space which may be flooded with water and the vessel still float in moderate weather.' Tabular statements are given for ships of various types, under different assumed conditions of loading, with cargoes of various densities. An enormous amount of labour was bestowed upon this portion of the report; but the detail is chiefly of interest to the expert, and for the average reader, or for the ship-owner, the deductions made by the committee from their experiments and calculations need alone receive attention. The committee's tables consequently contain implicit answers to the first questions put to them. Further, the committee deal, in general terms, with the no less important question of the heights in ships to which bulkheads should be carried in order to prevent the water rising above their tops when compartments are bilged. All these matters, however, involve no novelty in principle; and for any existing or proposed vessel can be very simply dealt with by direct calculations when limiting conditions have been fixed.

"The pith of this section of the report lies in the following extract:—

'Although all vessels, whatever their length, can be subdivided so as to be able to float in moderate weather with any two adjoining compartments in free com-

munication with the sea, yet if small vessels were subdivided to that extent their holds would be so reduced in length as to impair their value for commercial purposes. Having regard, therefore, to the exigencies of trade, we recommend that the following six grades be adopted, according to which certain vessels should be fitted with bulkheads in the manner indicated (Diagrams A and B) viz.:—

'First grade:—Vessels subdivided throughout their length so that they may float in moderate weather with any two adjoining compartments in free communication with the sea.

'This grade should apply to:—

(a) 'Sea-going steam vessels, whether paddle or screw, which have passenger certificates under the Merchant Shipping Acts, and which are not less than 425 ft. in length.

(b) 'Cross-channel steamers, irrespective of their length, whose principal employment is the carriage of passengers, or passengers and mails, as for instance, those running between Holyhead and Dublin or Kingstown, Dover and Calais, Folkestone and Boulogne, Newhaven and Dieppe, Liverpool and the Isle of Man.

'Second grade:—Vessels subdivided throughout their length so that they may float in moderate weather with any two adjoining fore-body compartments, or with any one after-body compartment, in free communication with the sea. A compartment the fore end of which does not extend more than a quarter of its length forward of the centre of the vessel's length may be treated as an after-body compartment.

'This grade should apply to sea-going steam vessels which have passenger certificates under the Merchant Shipping Acts and are less than 425 ft. but not less than 350 ft. in length.

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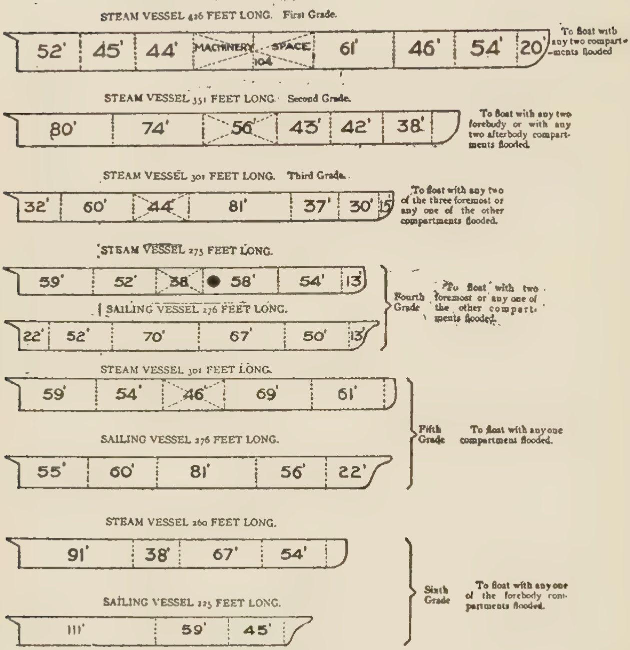
Diagram A.

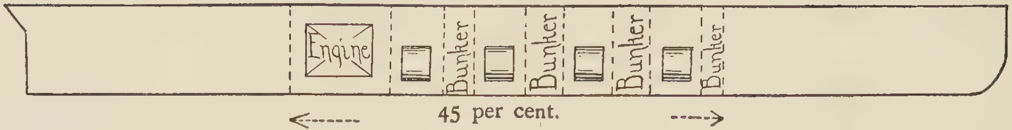
* Examples of possible subdivision in vessels of different lengths.



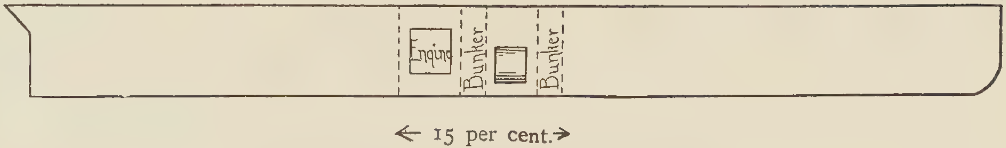
Water-tight Subdivision—Plate 3

DIAGRAM B.

Example of position and proportion of length taken up with machinery in a high powered vessel.



Example of position and proportion of length taken up with machinery in a low powered vessel.



WATER-TIGHT SUB-DIVISION—Plate 4.

'Third grade:—Vessels subdivided throughout their length so that they may float in moderate weather with any adjoining two of the three foremost compartments, or with any one of the other compartments, in free communication with the sea.

'This grade should apply to sea-going steam vessels which have passenger certificates under the Merchant Shipping Acts and are less than 350 ft. but not less than 300 ft. in length.

'Fourth grade:—Vessels subdivided through their length so that they may float in moderate weather with the two foremost compartments, or with any one of the other compartments, in free communication with the sea.

'This grade should apply to:—

(a) 'Sea-going steam vessels which have passenger certificates under the Merchant Shipping Acts and are less than 300 ft. in length.

(b) 'Sea-going sailing vessels, irrespective of their length, which carry more than 50 passengers in all, or a greater number of passengers, cabin or other, than in the proportion of one statute adult passenger to every 33 tons of the registered tonnage of such ships.

'Fifth grade:—Vessels subdivided throughout their length so that they may float in moderate weather with any one compartment in free communication with the sea.

'This grade should apply to:—

(a) 'Sea-going steam vessels not having passenger certificates under the Merchant Shipping Acts, and being not less than 300 ft. in length.

(b) 'Sea-going sailing vessels not coming under the fourth grade, and being not less than 275 ft. in length.

'Sixth grade:—Vessels subdivided in the fore-body so that they may float in moderate weather with any

one of the fore-body compartments in free communication with the sea.

'This grade should apply to:—

(a) 'Sea-going steam vessels not having passenger certificates under the Merchant Shipping Acts, and being less than 300 ft. but not less than 260 ft. in length.

(b) 'Sea-going sailing vessels not coming under the fourth grade, and being less than 275 ft. but not less than 225 ft. in length.

'Every vessel coming under any of the above categories should have her foremost bulkhead at a distance from the stem, measured along the load-line, not less than 5-100ths of the ship's length.'

"These are the practical recommendations upon which ship-owners and ship-builders have necessarily fixed attention, and upon which the Board of Trade had to decide whether action shall be taken. The *Rules for Life-Saving Appliances* issued by the Board in June, 1890, stated that 'When ships of any class are divided into efficient water-tight compartments to the satisfaction of the Board of Trade they shall only be required to carry additional boats, rafts, and other life-saving appliances of one-half of the capacity required by these rules.' What ship-owners need to know definitely is whether the grades of the committee will in future be the measure of 'the satisfaction of the Board of Trade.' For vessels in the first grade it appears that, at least, eight bulkheads would be required; for those in the second and third grades generally six bulkheads would suffice; for steamers in the fourth and fifth grades five bulkheads would be generally needed. Sailing vessels in the fifth grade would need four bulkheads.

"It will be noted that the committee only recom-

mended the extent of subdivision enabling any two compartments to be simultaneously open to the sea under their first grade. This includes all the largest and swiftest ocean-going steamers and all the cross-channel passenger steamers. Most persons will admit that this is no excessive requirement for vessels carrying large numbers of human beings. Experience shows, moreover, that in ocean-going steamers of the largest size this condition can be accepted without prejudice to the earning powers, so that the proposal only endorses the best existing practice. For cross-channel steamers cargo-carrying is of minor importance, and extension of subdivision will be treated chiefly in its bearing on accommodation. Possibly other methods of subdivision than the exclusive use of transverse bulkheads may find favour in such craft and be approved by the Board of Trade, which alternatives would involve no sensible decrease in safety.

"The *minimum* requirement for passenger steamers is found in the fourth grade; ignoring the collision bulkhead for a moment, although it has to be fitted, this *minimum* requirement amounts to an endorsement of the old Admiralty conditions. Any one compartment abaft the second bulkhead from the bow, or the space before that bulkhead, is not to involve the foundering of the vessel when the space is thrown open to the sea. This is certainly a very modest demand; but it applies to vessels which are of small dimensions.

"Between these extremes, under the second and third grades, come other passenger steamers. It is unnecessary to dwell upon the gradual increase of subdivision recommended with increase in size. The committee obviously attached great weight to the requirements for carrying and working cargo in these

vessels, wherein that section of the earnings has greater relative importance than in the largest steamers."

"The committee's proposals," continues the *Times' Reporter*, "for standard subdivision in passenger steamers do not go beyond, even if they quite approach, the best existing practice. Criticisms hereafter will probably come from advocates of minuter subdivision, on the ground that the safety of human life has not been put sufficiently high in comparison with commercial advantage.

"In dealing with cargo-steamers the committee clearly, and perhaps necessarily, put commercial considerations in the first place. For vessels above 300 ft. in length they recommend the old Admiralty condition; for vessels under 300 ft. in length and down to 260 ft. they practically give up any subdivision of the hold abaft the machinery space. It can hardly be supposed that even if a new law were passed on the subject of water-tight subdivision, it would be so framed as to bear hardly upon the owners of cargo-ships previously built and to involve expensive structural alterations. Taking the common-sense view, one would say that the committee wished to give somewhat greater safety to future cargo-carriers, and considered that this could be done without seriously diminishing commercial efficiency.

"Sailing ships carrying more than 50 passengers or more than one adult passenger to every 33 tons of registered tonnage are placed in the fourth grade, and are recommended to be subdivided so that they shall keep afloat with the two foremost compartments or any one of the other compartments open to the sea. This is a most important advance, the character of which will be understood from what has been said above,

particularly respecting emigrant ships. Other sailing vessels, cargo-carriers, are put upon the same terms as cargo-steamers of about 25 ft. greater length; and in these cases also a substantial advance on existing practice is recommended. Recently there have been considerable additions to the size and numbers of sailing ships, the safety of which would undoubtedly be much increased if the views of the committee were adopted without serious interference with the stowage or working of cargoes.

"The most perfect system of bulkheads may be rendered useless if proper care is not bestowed upon the arrangement and management of openings made in the sides of the ships (for light and air, for coaling, and for ports), and situated near the region of the water-line. The committee emphasize this fact, and propose various practical rules which would fully meet the case if adopted. They also enter into detail on the proper arrangements for making and working doors and passage-ways in bulkheads; but of these suggestions only one need be mentioned. It is that in merchant ships there should be a regular drill for closing water-tight doors, corresponding to the established drills in fire extinction and boat lowering. This applies especially to passenger steamers, and is well worthy of adoption by owners. Ideal bulkheads have no doors; in practice, easy communication fore and aft, at least in the engine and boiler spaces, is a necessity in both war- and merchant-ships. War vessels, with their numerous disciplined crews, have drills in closing doors without preparation or notice, thus simulating the conditions of accident. Merchant vessels carrying passengers should imitate this practice as a measure of precaution. It is true that such vessels have fewer men and much less stringent dis-

cipline; on the other hand, there are fewer doors and simpler subdivision.

"This naturally leads to the remark that the committee practically ignore all water-tight partitions except transverse bulkheads for merchant-ships. No doubt there are good reasons for their action. In war-ships, as a defence against torpedoes or other under-water attacks, nearly every partition primarily erected for stowage or accommodation is made water-tight, whether it be transverse, longtitudinal, or horizontal. Every cubic inch of space in the war-ship is assigned for some special purpose. On the contrary, in merchant-ships large hold spaces, are necessary for cargo carrying, and tranverse bulkheads are much the most convenient, besides being on the whole most efficient."

"The last paragraph of the report recalls attention to the fact that the Bulkheads Committee grew out of the Life-saving Appliances Committee. It runs as follows:—

'Having regard to the great additional safeguard which such subdivision as we have recommended would provide against loss, not only by collision or stranding, but also by fire, we would suggest that the Board of Trade might well offer a larger concession than that mentioned in Section 7 of the reference to this committee as an inducement to owners to subdivide their vessels to the extent that we have indicated under the several grades. We, therefore, submit that in such case owners might be relieved of the obligation to carry any part of the additional boats, rafts, and other life-saving appliances required by the rules issued by the Board of Trade under the Merchant Shipping (Life-Saving Appliances) Act, 1888.'

"This recommendation opened a way to the prac-

tical encouragement of efficient subdivision by the Board of Trade, under the provisions of the Act of 1888, and as interpreting the Rules of 1890. It has already been remarked that strong adverse opinions have been expressed with reference to the multiplication of boats and life-saving appliances. This is particularly true as regards the equipment of sea-going vessels. In fact it is undeniable that such appliances are chiefly of service in keeping people afloat for limited periods supposing rescue to be at hand. And, further, in passenger steamers carrying large numbers of people, it is difficult, or as many say, practically impossible, to arrange the boats and life-saving gear so that they may be at once available. To carry many boats that can be got out with difficulty, and which cannot be efficiently manned by the limited crew even if got out, is little real gain. But to keep the ship herself afloat, even when seriously damaged, must always be advantageous; and if she sinks ultimately, to gain time for getting people and provisions into boats, must be of value.

"Without unduly reducing boats and life-saving appliances, the committee's recommendation put a premium on increased subdivision, by enabling the well divided ship to gain in equipment upon the ill-divided vessel.

"This the Board of Trade can do without new legislation. After persevering for 30 years on the principle of non-interference with the structural arrangement of ships, the Department will, no doubt, require strong reasons for a change of policy and for a return to compulsory legislative enactments respecting water-tight subdivision. The existing practice of the Board of Trade in dealing with the machinery and boilers of passenger steamers is held, in many quarters,

to hamper progress and fetter ingenuity. Strong opposition would therefore be raised to legislation on the subject of bulkheads, and it is to be hoped that the proper security of passengers and crews over the high seas will be insured by the voluntary action of ship-owners and the pressure of competition. The standard of efficiency in all features of ship construction is continuously being raised by the leaders in ship-building and ship-owning, and, where they lead, others must eventually follow."

Since the report of the Committee was presented the Board of Trade has used its powers under the Act of 1888 to insist upon the full provision of life-saving appliances or satisfactory subdivision. Beyond this indirect use of their recommendations the Committee has had little public recognition of their work. Recently, at the annual meetings of the Institution of Naval Architects, the late Sir Edward Harland spoke, with considerable feeling, of the report 'being under a cloud,' and vigorously defended the character of the work which was done and the recommendations made. There can be no doubt but that Sir Edward Harland and his colleagues deserve the gratitude of all interested in shipping for the manner in which this important inquiry was conducted. The diagrams show very clearly what the view of the committee was as to the reasonable and fairly safe division of ships. The action of the President of the Board of Trade in giving such an indication of the future road for ship-builders and ship-owners should receive national commendation, whether it is embodied in legislation or not. Sir Edward Harland has since died and the author feels that it is only just, in this connection, to lay a wreath upon his grave. When the enquiry with which the writer was connected

twenty years ago, which resulted in the report of Mr. Dunn, was made, it was not possible to find anywhere in Great Britain a builder who rose above the level set by the Board of Trade and Lloyds' Committee and gave such subdivision in the large liners and other ships built by him as is embodied in the recommendations made in 1890 by the Bulkhead Committee. It was only in Ireland that this was done, and the builder was Harland.

The Bulkhead Committee did not look so much for fresh legislation or the influence of Registries as for action by the Board of Trade surveyors in enforcing the better subdivision through concessions in other directions. The action taken by the Board of Trade as expressed in the instructions to surveyors is as follows:—"When ships of any class are divided into efficient water-tight compartments to the satisfaction of the Board of Trade, they shall only be required to carry additional boats, rafts, and buoyant apparatus of one-half of the capacity required by these rules, but the exemption shall not extend to life jackets or similar approved articles of equal buoyancy suitable to be worn on the person."

Turning to the instructions as to bulkheads in the Board of Trade regulations dated 1896 we find no reference to the recommendations of the committee. The rule is "an efficient and water-tight engine-room and stoke-hole bulkhead, as well as a water-tight bulkhead, and an after water-tight compartment to enclose the stern tube of each screw shaft, should be fitted in all sea-going steamers, both new and old, and in the absence of any of these the case must be specially referred to the Board of Trade before a declaration is given. *As regards other bulkheads, although subdivision of the ship is desirable, the surveyors should*

not for the present refuse to grant a declaration because they had not been fitted.

In other words no control is proposed is the direction recommended by the committee even for passenger steamers. All other steamers and all sailing ships, whether carrying passengers or not, are left without inspection in respect of bulkheads.

The writer has long been of opinion, and he has been supported in it by Lord Brassey and other leaders of public opinion, that the Marine Department of the Board of Trade should be greatly strengthened. This would not necessarily involve vexatious interference with trade. It should carry a more intelligent guidance and help in the arrangements in the ships. Owners are not adverse to regulations which are fair all round, and do not give special advantages to foreign ships, provided it can be shown that the general character of British shipping can be raised thereby.

The service performed by the Admiralty in this matter received very generous recognition from shipbuilders. Mr. William Denny said in 1882, "The Admiralty and especially Mr. Barnaby may claim for themselves that in the water-tight subdivision of hulls they have revolutionised the merchant service. They sounded the first note of alarm upon that point, and they have since utilised the interests which they raised in developing a right system of water-tight subdivision. Mr. Dunn has remarked that the division of a steamer's hull into many compartments involves some slight expense, but although it may involve expense I am able to say from the experience of shipowners for whom my firm has built that it involves also large conveniences. The steamers which trade between India and this country have, not only to do a service between terminal ports, but they have, further,

to do a service between their owners' intermediate ports, and find it of very great value, instead of having large holds in length and capacity, to have holds in which they may place with ease the stowage for each separate port and discharge it at once, when they arrive there, without disturbing the stowage for the terminal ports. We may congratulate Mr. Barnaby and the Admiralty that they have not merely introduced a change into the merchant service which has been useful from a point of view of safety, but which has been useful commercially."

APPENDIX TO WATERTIGHT SUBDIVISION.

(Note, by the Author, upon the loss of H. M. S. Victoria, on 22nd June, 1893, from the effects of a collision, as to the bearing of the circumstances of the loss upon the efficiency of bulkhead division.)

I have never been called upon to offer any explanations as to the arrangements in the Victoria, although the design of the ship was due to me, and I certainly should have been had there been any alleged deficiency in bulkhead subdivision, or any error of judgment in the arrangements for making the water-tight doors and scuttles effective.

Nor has there been charged against the ship that an insufficient amount of stability was provided to meet such an accident.

Yet the fact remains that in this ship all that bulkheads can be made to do was under the control of a large and highly disciplined crew and that nevertheless she sank in smooth water from a single blow. It has been suggested that this will be remembered in disparagement of the usefulness of bulkheads unless

the results of the Admiralty enquiry of 1893 are recalled and set forth.

It will be remembered that the technical part of the investigation was conducted by Sir William White, the Director of Naval Construction, although he was not responsible for the design of the ship. He was known throughout the shipbuilding world as being not only the most competent man upon whom the duty could possibly have fallen, but of being also incapable of improperly screening the designer from any blame which was due to him. The designer of the ship was satisfied on his part that the Board of Admiralty would do justice to the ship in any apportionment of blame between the structure and the control.

In making this investigation and report the Director of Naval Construction was following precedent. When in 1875 the "Vanguard," a completely armour-belted ship, was sunk in the Irish Sea as the result of a collision, it was not her designer but his successor in office who investigated and reported on the circumstances as they affected the design of the ship.

The energy of the blow delivered by the "Iron Duke" which sank the "Vanguard" was estimated to have been the energy of the 25-ton gun M. L. gun at the muzzle, and that of the blow delivered by H. M. S. "Camperdown" to have been equivalent to that of the 45-ton B. L. gun at the muzzle. The ram of the "Camperdown" was, moreover, more prolonged than that of the "Iron Duke."

The Admiralty minute on the question of closing the water-tight doors, and on the construction and stability of the ship was as follows:—

1. "The capsizing of the 'Victoria' under the special circumstances above described does not suggest

any insufficiency of stability in the design of that vessel. The provision made was ample for all requirements. When fully laden and in sea-going trim the metacentric height was five feet, stability reached its maximum at an angle of $34\frac{1}{2}$ degrees to the vertical, and the range of stability was $67\frac{1}{2}$ degrees.

2. "The question remains, what would probably have happened if all doors, hatches, etc., had been closed in the 'Victoria' before the collision took place. Investigation shows that while the loss of buoyancy must in that case have been considerable, yet, making all due allowance for probable damage, the ship would have remained afloat, and under control, and able to make port under her own steam. Her bow would have been depressed about to the water-level; her heel to starboard would have been about one-half of that observed before the lurch began; her battery ports would have been several feet above water, and she would have retained ample stability.

3. "The evidence clearly shows that the existence of longitudinal water-tight bulkheads in the 'Victoria' was not the cause of her capsizing. There were only a few minor longitudinal partitions in the fore part of the ship. Many of these were inoperative because of damage or open doors.

"It also proves that the loss of the ship was not due to injuries sustained above the protected deck. Those injuries produced a loss of buoyancy forward which was unimportant compared with that resulting from the flooding of compartments below the protective deck.

4. "The fact that the 'Victoria' was not armour-belted to the bow had no influence upon the final result of the collision. No armour-belt could have prevented the ripping open of the bottom below water

by the ram-bow of the 'Camperdown' and the flooding of the compartments to which water could find access through the breach.

5. "In conclusion, their Lordships are of opinion that the general structural arrangements of the 'Victoria' (similar in many respects to those of other ships in Her Majesty's navy), with the arrangements of water-tight doors, armoured belt, and protective deck, did not by any fault of principle contribute to the loss of the ship; but that, on the contrary, had the water-tight doors, hatches, and ports been closed, the ship would have been saved, notwithstanding the crushing blow which she received from the 'Camperdown.'

6. "The duty remains of taking every possible step to prevent the recurrence, under similar circumstances, of the conditions which, after the collision, resulted in the loss of the ship.

"Regulations will therefore be issued to the fleet which, while maintaining the responsibility and discretionary powers of commanding officers, will insure that, under special circumstances, and particularly when there is risk of collision, doors, hatches, etc., shall be kept closed as far as possible, and men stationed at any that are necessarily left open.

"These regulations will also direct that, under certain conditions arising out of collision, or under-water attack, the gun-ports and other openings in the upper structure shall be closed before water can enter and endanger the stability of the ship."

It is from this minute quite evident that no argument can be based on the loss of the "Victoria" against the value of bulkheads. The lessons affect the management of the doors and scuttles. They were much needed for there are no people anywhere so

careless of their lives and so unwilling to take precautions for their preservation as are British seamen.

As to the provision necessary for keeping efficient control of water-tight doors and scuttles, I have long ago declared that, in my judgment, the only satisfactory way is to station a watch at every such door or scuttle which is under water and must be open, and that such a rule should be enforced in every commissioned ship, except when she is at moorings in a home port. The duty of such a watch should be to use the efficient means placed under his control for closing or securing such door or hatch when the call is made by bugle or pipe.

If this were also made the rule in passenger ships the public would soon learn the value of the additional security to life in such ships.

CHAPTER XIII.

MODEL EXPERIMENTS IN AID OF NAVAL DEVELOPMENT.

Soon after the formation of the Institution of Naval Architects and Marine Engineers in England Mr. William Froude set up at Torquay under the auspices of the Admiralty an establishment for experimenting upon the resistances and speeds of models of ships.

Up to this time there had been books written and theories formed on fluid resistance and ship-builders thought they knew much upon the subject. But before 1870, men worked really in the dark. The establishment at Chelston Cross, Torquay was destined to throw a flood of light upon the subject and the Civil Engineer Wm. Froude, trained under Brunel on the West Country Railways and in the preparatory work for the great steamships—to him the nineteenth century owes a very large part of its distinction. If the author had to choose a man whose portrait should be in the front of these pages as more representative than any other of the foremost workers in Naval Development during a wonderful century he thinks he would find himself supported by the ship-builders all over the world in choosing Mr. Froude.

In supporting this enterprise on its first inception the British Admiralty was advised by Admiral Sir Robert Spencer Robinson then controller of the Navy, Dr. Woolley and Sir Edward Reed, the Chief Con-

structor who had been Secretary to the Institution of Naval Architects.

Without this advice it is inconceivable that the Admirals would have agreed to spend money on playing with models in a tank. But this tank was destined to be famous. Mr. Froude devoted himself and his private means absolutely to this enterprise and it was a delight to go with him into the story of the arrangements and devices by which he sought to combine accuracy and simplicity in the apparatus. The tank, the house, the travelling machinery, the measuring and timing apparatus, the model making—everything was original and efficient. The establishment was eventually transferred to Haslar and is now a recognised part of the outfit of the Designing Staff. It is presumed that there is no difficulty now in securing the inclusion of the necessary expenditure in Naval Estimates, but for years it was necessary to colour a little the reports of progress in order to secure the annual subsidy to the Torquay Works. Mr. Froude himself was incapable of using a word of exaggeration. He was an ideal observer. His friends and colleagues who believed in him felt themselves honoured in looking forward with him past the unavoidable delays and difficulties to an assured success.*

The object of the Establishment was to submit to experiment various proportions and forms of ships in model in order to compare the relative resistances in the same model at various speeds, and in different

*Every new design for a ship of war for the state is now tested in models by the Froude methods not only in England but also in Germany, Russia, Denmark, and in the United States of America.

forms and proportions in several models of equal speeds. There was reason to doubt whether a model on a scale of $\frac{3}{4}$ of an inch to a foot would give useful information as to what would happen in the ship which it represented. Would a measurement of the model resistance of a speed which corresponded with that of the ship represent truly the resistance in the ship and would the wave phenomena represent in a tank what would happen in the open sea?

Mr. Froude's account of the phenomena and of the assumptions made in the experiments is as follows:—

"If a ship be D times the 'dimension,' as it is termed, of the model, and if at the speeds V_1 V_2 V_3 . . . . the measured resistances of the model are R_1 R_2 R_3 . . . . , then for speeds $D^{\frac{1}{2}}$ V_1, $D^{\frac{1}{2}}$ V_2, $D^{\frac{1}{2}}$ V_3, ... of the ship, the resistances will be D^3 R_1, D^3 R_2, D^3 R_3 . . . . . To the speeds of model and ship thus related it is convenient to apply the term 'corresponding speeds.' For example, suppose two similar ships, the length, breadth, depth, etc., of which were double one of the other. Then, if at a given speed (say 10 knots) the resistance of the smaller ship were ascertained, we may infer that at a speed of $\sqrt{2} \times 10 = 14.14$ knots in the larger ship there would be a resistance eight times as great as in the smaller vessel."

"This law is in accordance with the old rule that the resistance varies as the square of the velocity, and also as the area of the surface exposed to resistance. It takes into account both the resistance due to surface friction (subject to some correction) and the formation of deadwater eddies. The passage of the ship through the water creates waves which are dependent for their character upon the proportions and form of the ship. These constitute also an element of resist-

ance. They are due to differences of hydrodynamic pressure inherent in the system of stream-lines which the passage of the ship creates. These wave-configurations should be precisely similar when the originating forms are similar and are travelling at speeds proportional to the square roots of their respective dimensions, because the resulting forces will be in that case as the square of the speeds. For example, if the surface of the water surrounding a ship 160 feet long, travelling at 10 knots an hour, were modelled together with the ship, on any scale, the model would equally represent, on half that scale, the water surface surrounding a ship of similar form 320 feet long, travelling at 14.14 knots an hour; or again, on 16 times that scale, the water surface surrounding a model of the ship 10 feet long, travelling at 2½ knots. Experiment has abundantly confirmed this proportion as to the similarity of waves caused by similar forms travelling at corresponding speeds. The resistance caused to these forms respectively by the development of the waves would therefore also be proportionate to the cubes of the dimensions of the forms and would follow the law of comparison stated above. It is necessary, however, to observe that, in dealing with surfaces having so great a disparity in length and speed as those of a model and of a ship, a very tangible correction is necessary in regard to surface friction."

The vessel tried by Mr. Froude for confirming the law of comparison was H. M. S. "Greyhound," of 1157 tons. She was towed by H. M. S. "Active," of 3078 tons, from the end of a boom 45 feet long, so as to avoid interference of "wake." It was found to be possible to tow up to a speed of nearly 13 knots. The actual amount of towing strain for the "Greyhound" was approximately as follows:—At 4 knots, 0.6 ton;

at 6, 1.4 tons; at 8, 2.5 tons; at 10, 4.7 tons; and at 12, 9.0 tons.

"Comparing the indicated horse-power of the 'Greyhound' when on her steam trials and the resistance of the ship as determined by the dynamometer, it appears that, making allowance for the slip of the screw, which is a legitimate expenditure of power, only about 45 per cent of the power exerted by the steam is usefully employed in propelling the ship, and that the remainder is wasted in friction of engines and screw and in the detrimental reaction of the propeller on the stream lines of the water closing in around the stern of the vessel.

"The system of experiments involved the construction of models of various forms (they are really fair-sized boats of from 10 to 25 feet in length), and the testing by a dynamometer of the resistances they experienced when running at various assigned appropriate speeds. The system may be described as that of determining the scale of resistance of a model of any given form, and from that the resistance of a ship of any given form, rather than as that of searching for the best form, and this method was preferred as the more general, and because the form which is best adapted to any given circumstances comes out incidently from a comparison of the various results. We drive each model through the water at the successive assigned appropriate speeds by an extremely sensitive dynamometrical apparatus, which gives us in every case an accurate automatic record of the model's resistance, as well as a record of the speed. We thus obtain for each model a series of speeds and the corresponding resistances; and, to render these results as intelligible as possible, we represent them graphically in each case in a form which we call the 'curve of the

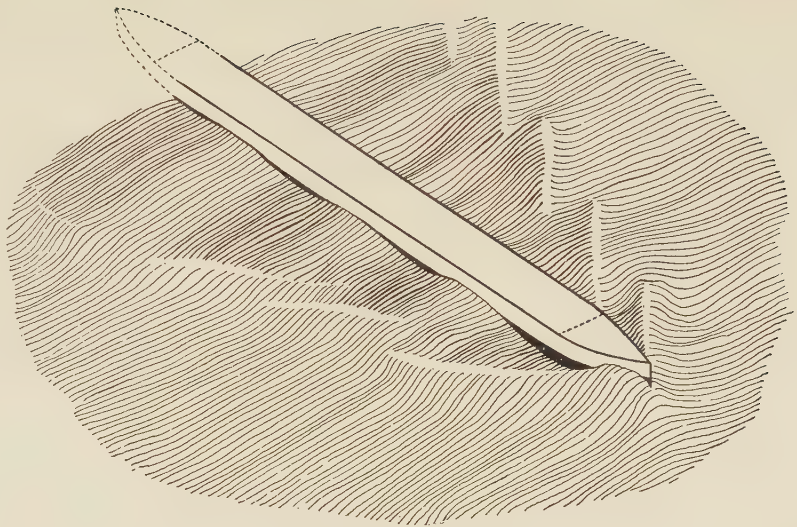
resistance' for the particular model. On a straight base line which represents speed to scale we mark off the series of points denoting the several speeds employed in the experiments, and at each of these points we plant an ordinate which represents to scale the corresponding resistance. Through the points defined by these ordinates we draw a fair curved line, and this curve constitutes what I have called the curve of resistance. This curve, whatever be its features, expresses for the model of that particular form what is in fact and apart from all theory the law of its resistance in terms of its speed; and what we have to do is if possible to find a rational interpretation of the law. Now we can at once carry the interpretation a considerable way; for we know that the model has so many square feet of skin in its surface, and we know by independent experiments how much force it takes to draw a square foot of such skin through the water at each individual speed. The law is very nearly—and for present convenience we may speak as if it were exactly—that skin resistance is as the area simply, and as the square of the speed. Now, we have so many square feet of immersed skin in the model, and the total skin resistance is a certain known multiple of the product of that number of square feet and of the square of the speed. Now, when we lay off on the curve of resistance a second curve which represents that essential and primary portion of the resistance, then we find this to be the result: the curve of skin resistance when drawn is found to be almost identical with the curve of total resistance at the lower speeds; but as the speed is increased the curve of total resistance is found to ascend more or less, and in some cases to ascend very much above the curve of skin resistance. The identity of the two curves at

the lower speeds is the practical representation of a proposition which the highest mathematicians have long been aware of, and which I have lately endeavoured to draw the public attention to, and to render popularly intelligible, namely, that when a ship of tolerably fine lines is moving at a moderate speed the whole resistance consists of surface friction. The old idea that the resistance of a ship consists essentially of the force employed in driving the water out of her way, and closing it up behind her, or, as it has sometimes been expressed, in excavating a channel through the track of water which she traverses,—this old idea has ceased to be tenable as a real proposition, though *prima facie* we know that it was an extremely natural one. We now know that, at small speeds, practically the whole resistance consists of surface friction, and some derivative effects of surface friction, namely, the formation of frictional eddies, which is due to the thickness of the stem and of the sternpost; but this collateral form of frictional action is insignificant in its amount unless the features of the ship in which it originates are so abruptly shaped as to constitute a departure from that necessary fineness of lines which I have described; and we do not attempt to take an exact separate account of it.

"Thus we divide the forces represented by the curve of resistance into two elements,—one 'skin resistance,' the other which only comes into existence as the speed is increased, and which we may term 'residuary resistance.' And we have next to seek for the cause and governing laws of this latter element. Now when the passage of the model along the surface of the water is carefully studied, we observe that the special additional circumstance which becomes apparent as the speed is increased is the train of waves which she

puts in motion; and indeed it has long been known that this circumstance has important bearings on the growth of resistance. It is in fact certain that the constant formation of a given series involves the operation of a constant force, and the expenditure of a definite amount of power, depending on the magnitude of those waves and the speed of the model; and, as we thus naturally conclude that the excess of resistance beyond that due to the surface friction consists of the force employed in wave-making, we in a rough way call that residuary resistance 'wave-making resistance.'

"Perhaps I had better say a few words more about the nature and character of these waves. The inevitably widening form of the ship at her 'entrance' throws off on each side a local oblique wave of greater or less size according to the speed and to the obtuseness of the wedge, and these waves form themselves into a series of diverging crests, such as we are all familiar with. These waves have peculiar properties. They retain their identical size for a very great distance with but little reduction in magnitude. But the main point is that they become at once dissociated from the model, and after becoming fully formed at the bow, they pass clear away into the distant water and produce no further effect on her resistance. But, besides those diverging waves, there is produced by the motion of the model another notable series of waves which carry their crests transversely to her line of motion. Those waves, when carefully observed, prove to have the form shown in detail in the accompanying illustration. In the figure there is shown the form of a model which has a long parallel middle body accompanied by the series of these transverse waves as they appear at some one particular speed



A MODEL EXPERIMENT

with the profile of the series defined against the side of the model. It is seen that the wave is largest where its crest first appears at the bow, and it reappears again and again as we proceed sternwards along the straight side of the model, but with successively reduced dimensions at each reappearance. That reduction arises thus:—In proportion as each individual wave has been longer in existence, its outer end has spread itself farther into the undisturbed water on either side, and, as the total energies of the wave remain the same, the local energy is less and less, and the wave-crest, as viewed against the side of the ship, is constantly diminishing. We see the wave-crest is almost at right angles to the ship, but the outer end is slightly deflected sternward from the circumstance that when a wave is entering undisturbed water its progress is a little retarded, and it has to deflect itself into an oblique position, so that its oblique progress shall enable it exactly to keep pace with the ship. The whole wave-making resistance is the resistance expended in generating first the diverging bow waves, which, as we have seen, cease to act on the ship when once they have rolled clear of the bow; secondly, these transverse waves, the crests of which remain in contact with the ship's side; and, thirdly, the terminal wave, which appears independently at the stern of the ship. This latter wave arises from causes similar to those which create the bow wave, namely, the pressure of the streams which, forced into divergence then, here converge under the run of the vessel, and re-establish an excess of pressure at their meeting. The term 'wave-making resistance' represents, then, the excess of resistance beyond that due to surface friction, and that excess we know to be chiefly due to this formation of waves by the ship.

"The waves generated by the ship in passing through the water originate in the local differences of pressure caused in the surrounding water by the vessel passing through it; let us suppose, then, that the features of a particular form are such that these differences of pressure tend to produce a variation in the water level shaped just like a natural wave, or like portions of a natural wave of a certain length.

"Now an ocean wave of a certain length has a certain appropriate speed at which only it naturally travels, just as a pendulum of a certain length has a certain appropriate period of swing natural to it. And, just as a small force recurring at intervals corresponding to the natural period of swing of a pendulum will sustain a very large oscillation, so, when a ship is travelling at the speed naturally appropriate to the waves which its features tend to form, the stream-line forces will sustain a very large wave. The result of this phenomenon is, that as a ship approaches this speed the waves become of exaggerated size, and run away with a proportionately exaggerated amount of power, causing corresponding resistance. This is the cause of that very disproportionate increase of resistance experienced with a small increase of speed when once a certain speed is reached.

"We thus see that the speed at which the rapid growth of resistance will commence is a speed somewhat less than that appropriate to the length of the wave which the ship tends to form. Now, the greater the length of a wave is the higher is the speed appropriate to it; therefore, the greater the length of the waves which the ship tends to form the higher will be the speed at which the wave-making resistance begins to become formidable. We may therefore accept it as an approximate principle that the longer are

the features of a ship which tend to make waves the higher will be the speed she will be able to go before she begins to experience great wave-making resistance, and the less will be her wave-making resistance at any given speed. This principle is the explanation of the extreme importance of having at least a certain length of form in a ship intended to attain a certain speed; for it is necessary, in order to avoid great wave-making resistance, that the 'wave features,' as we may term them, should be long in comparison with the length of the wave which would naturally travel at the speed intended for the ship.

"This view of the matter, then, recognizes the tendency of a ship, when the speed bears a certain relation to the length of her wave-making features, to make large waves and to incur corresponding wave-making resistance. But it does not take account of the possibility of the waves made by one feature of the form so placing themselves with reference to other features as, by the differences of pressure essential to their existence, either to cause an additional resistance, or on the other hand to cause a forward force which partly counterbalances the resistance originally due to their creation. The way in which this may occur we have seen strikingly exhibited in the results of the experiments I have been describing. We see that in the very long parallel-sided form the sternmost of the train of waves left by the bow has become so small that its effect on the stern is almost insensible; and here we find, consequently, the united resistance due simply to the generation of a separate wave-system by each end of the ship. As we gradually reduce the length of middle-body, the stern is brought within the reach of waves large enough to produce a sensible effect, and according as it is

brought into conjunction with a crest or hollow, the total wave-making resistance becoming least of all (except at the very highest speed) when the middle-body is reduced to nothing.

"The variations in residuary resistance due to these transverse wave-formations are variations of quasi-hydrostatic pressure against the after-body, corresponding with the changes in its position with reference to the phases of the train of waves, there being a comparative excess of pressure (causing a forward force or diminution of resistance) when the after-body is opposite a crest, and the reverse when it is opposite a trough.

"By a 'perfect fluid' is meant one the displacements of which are governed solely by the laws expressed in the equation of fluid motion, the particles of which therefore are without viscosity, and are capable of gliding rectilinearly along a perfectly smooth surface or past each other without frictional interference. By an imperfect fluid is meant one in which, as in water, as well as those with which we are practically acquainted, such frictional interference is inevitable.

"Dealing first, then, with the case of steady rectilinear motion in a perfect incompressible fluid, infinitely extended in all directions, it is plain that the motion will create differences of pressure, and therefore changes of velocity, in the particles of the surrounding fluid, which thus move in what are called 'stream lines.' At the commencement of the motion of the body the particles of the fluid undergo acceleration in their respective stream-line paths, and these accelerations imply a resistance experienced by the body; but after the motion has become established the differences of pressure satisfy themselves by keeping up the stream-line configuration; the energy which the

particles receive from the body while they are being pushed aside by it along their stream-line paths is finally redelivered by them to it as they collapse around it, and come to rest after its passage, and the integrals of the + and − pressures on the body are exactly equal at every moment. The manner in which this is effeced is governed by the general laws of fluid motion, as expressed by the well-known equations; and, since these equations contain no term which implies a loss of energy, the energy existing in the body, as well as in the stream-line system, remains unaltered; so that, if the motion is steady, or without acceleration or retardation, the body passes through this theoretically perfect fluid absolutely without resistance. Nor must it be thought a paradox (for it is unquestionable) that even a plane moving steadily at right angles to itself through a perfect fluid would in the manner described experience no resistance. But if the fluid, instead of being infinite in all directions, be bounded by a definite free surface parallel to the line of motion, such as a water level, the existence of this surface cuts off the reactions of all those particles which would have existed beyond the surface had the fluid been unlimited alike in all directions, and which would have given back in the manner described the energy imparted to them. By the absence of these reactions the stream-line motions which would have existed in the infinite fluid are modified, and the differences of pressure involve corresponding local elevations of the surface of the water in the vicinity of the moving body. And since, in consequence of the action of gravitation (the force which controls the surface), a water protuberance seeks immediately to disperse itself into the surrounding fluid in accordance with the laws of wave motion, the local elevation partly dis-

charges itself along the surface by waves which carry with them the amount of energy embodied in their production. This energy is, in fact, part of the aggregate energy which was imparted to the particles of fluid while they were being pushed aside, and which, in the infinitely extended fluid, would have been wholly restored to the body during their collapse after its passage, but is now, in fact, dissipated. The exact quality between the + and − pressures no longer exists, and the body experiences a definite resistance which it would not do if the fluid were infinite in all directions.

"It is clear, moreover, that the nearer the moving body approaches the surface the greater are the differences of pressure to be satisfied, the greater will be the waves formed, and the greater the dissipation of energy. Thus, for example, a fish will experience an increase of resistance as its path lies nearer to the surface, the train of waves it creates becoming then a visible accompaniment of its progress. *A fortiori*, when the body moves along the surface as a ship does on water, those differences of pressure which would exist during the motion if the fluid were infinite in all directions satisfy themselves in still larger waves, which, in fact, are the waves which accompany the body in its motion. The waves which thus visibly accompany a vessel *in transitu* form a marked phenomenon in river steaming. Thus we see how, although in a perfect fluid extended infinitely in all directions, a body, when once put in motion, would move absolutely without resistance, yet, when the fluid is bounded by a gravitating surface at or near the line of motion, the body will experience resistance by the formation of waves, notwithstanding that the fluid is a perfect one.

"If the fluid is again supposed to be infinite in all directions, but imperfect, the phenomena previously described undergo appropriate modifications, and the moving body will also suffer a specific resistance,—in the first place by its having to overcome the friction and viscosity of those particles of the fluid with which it is in contact, and next because the friction of the surrounding particles *inter se* destroys that orderly arrangement of the stream-line configuration which allows of the energy imparted to the particles being returned without loss. If the supposed imperfect fluid is bounded by a free surface, as already described, and the body moves at or near this surface, it will experience resistances depending on fluid friction, almost exactly in the same manner as if the fluid were infinite in all directions. It will also experience very nearly the same resistance in virtue of the wave-making action as in the perfect fluid; and we here see the two sources of resistance existing independently of each other, and due to totally different causes."

The various experimental establishments in existence in all parts of the world have been modelled on the lines of that at Chelston Cross.

Mr. Denny of Dumbarton in Scotland, described that in operation at the Leven shipyard at a recent Engineering Conference.

The tank itself is 300 feet long: For 250 feet it is 22 feet broad and ten feet deep and contains in all about 1,500 tons of fresh water. The remaining fifty feet of length consists of two shallow docks, one at each end, constructed for convenience in ballasting, trimming and other such operations.

Over the water, supported on suitable beams and girders is a double line of rails, the distance between

the rails being 3 feet 4 inches. On these rails run a dynamometer truck and screw truck, which are drawn along by an endless wire rope and an ordinary two-cylinder engine. The governor designed by Mr. R. E. Froude is extremely sensitive. The model floats underneath the dynamometer truck to which it is connected by means of a spring the extension of which is measured as a measure of the resistance to the model at the various speeds used. The model is free to move either longitudinally or vertically but is prevented from moving transversely by guides.

The extension of the spring is multiplied about eleven times by a lever which carries the recording pen, this pen writes the record of strains on paper stretched on a revolving drum. The electric pens mark time and distance—one marks every half second from a carefully standardised clock fitted with electric contacts, the other marks every ten feet by means of contacts at the side of the rails. A third pen is attached to a governor and indicates whether speed has been constant throughout the run. If it is not, diagrams are useless.

The propeller or propellers are driven in their proper positions at the stern of the ship at arranged speeds from the following screw truck.

The thrust and turning force of the screws are measured and marked as in the case of the resistances on the model.

Thus the dynamometer truck gives the means of ascertaining the resistance of a model, and from the screw truck the thrust revolutions and the turning force necessary to drive the screw or screws is obtained and from this the required horse-power of the engine to give the designed speed in the ship represented in miniature.

The apparatus is of extreme delicacy. All the levers are hung on knife edges or flat springs, and all the wheels in the screw truck are either working on ball bearings or Atwood pulleys. The quantities dealt with especially at low speeds are extremely minute. It is believed that results are obtained to within one-tenth of one per cent of the truth.

The models are cast in paraffin wax and cut to shape by a copying machine fitted with rotary cutters designed by Mr. William Froude, and afterwards finished by hand. They represent accurately the actual ships and the displacement is checked by weighing the model and ballast against the displacement at a certain water-line.

The principle upon which the tank results are used in predicting speeds and power depends, so far as the resistance of the ship is concerned, upon Mr. Froude's law of comparison.

Mr. Denny gives some instances of the usefulness of this system.

In 1887 the Belgian government wished to purchase fast paddle steamers to improve their Ostend and Dover service. A thorough investigation was commenced in the tank and started with a vessel 300 feet long, 35 feet broad, with a draught of water of about 8½ feet.

After making several models it was found that the best speed which could be guaranteed would not be more than about 19½ knots. Dissatisfied with this as it did not exceed what had already been done, it was determined to continue experimenting with a view to doing better. Among others a model was tried with the same draught of water and length, but 38 feet broad, the displacement being the same. It was found that instead of being able to

guarantee only $19\frac{1}{2}$ knots, $20\frac{1}{2}$ knots could be guaranteed.

The two vessels which were the practical results of these experiments the "Princess Henriette" and the "Josephine" each did a speed of 22.1 knots on a prolonged and severe trial. Model paddles driven by an electric motor were tested along with the model. Apart from the question of resistance a most important question in a paddle boat is the position of the paddles as affecting the immersion of the wheels. If proper allowance for longitudinal waves is not made all calculations may be upset by the discovery that at the proper speed for the ship there is a wave crest or a wave hollow at the paddles which either increases or diminishes their required immersion and efficiency. In the case of these two steamers the position of a wave hollow at the wheels was seen to give a depression of 10 inches below the surface at $20\frac{1}{2}$ knots to which the wheels had to be accommodated.

Having stated how the tank has helped in the production of paddle steamers by the prediction of the actual wave profile with a given form and speed of ship, Mr. Denny gives instances of the value of screw experiments. What has been found out, he says, is both for ships and screws that there is no such thing as a perfect form of ship but that the form must vary with every varying condition of length, draft of water, displacement and speed. Also that there is no perfect form of screw and that the screw of one ship which might give a phenomenally good result on that ship would, as likely as not, give a phenomenally bad result on another, and different type of vessel.

Mr. Denny gives a case of a vessel where the tank signally helped them in the matter of propellers. The

vessel was 270 feet long and the speed was to be $17\frac{1}{2}$ knots with twin screws. Power for fully 18 knots was allowed for but the result in the ship was only $17\frac{1}{2}$ knots and that with an abnormal expenditure of power. Numerous trials were made and it was found that by trimming the vessel nearly level as against $1\frac{1}{2}$ feet by the stern the speed was increased by about one-half a knot. This showed that there was something wrong with the stream lines aft in which the action of the screws was influential. Trials were then undertaken in the tank with various shapes of propellers and various areas of blades. Finally the tank predicted that if a propeller of the same diameter, and the same pitch, but with about 20 per cent more surface were fitted the speed at normal draught and trim would be increased one-half a knot. This was done and the predictions of the tank were fulfilled.

In one case where the vessel was required to be navigated in shallow water the speed asked for was thought to be beyond what could be got in a very shallow river. A false bottom was fitted to the tank to represent this and the experiment showed that the deep water resistance might be easily increased by 50 per cent in moderately shallow water.

Speaking after the use of the tank for ten years Mr. Denny says that it saves the designers many a sleepless night and anxious day.

It is clear that the great cost of experiments made in actual ships would be enough to limit the information which could be gained in these all important matters, and, apart from cost, the varying conditions of wind and weather would make precision quite unattainable.

At the Summer Session, 1901, of the Institution of Naval Architects and Marine Engineers it was decided

that the time had come when there should be a Froude experimental tank in England or Scotland or both which should be accessible to the public. The works to be under the control of an expert who would take care that all investigation should be treated confidentially in the interests of the designers of the models submitted to experiment.

The proposition accepted and adopted by the meeting was as follows:—

"That this meeting having regard to the desirability of establishing a tank in this country for testing the resistance of models and which might be available for all shipbuilders request the Council of the Institution to take the matter into serious consideration with a view to arriving at the best means of carrying out the suggestion."

CHAPTER XIV.

CO-OPERATION IN NAVAL DEVELOPMENT.

In official life in Great Britain as in that of other European countries the virtue of secrecy is highly valued.

That fine word "confidential" is much esteemed. Sometimes there is a confidential enquiry into some important national concern. First rate men are on the commission. Witnesses are examined whose evidence is of the highest value and a report follows. This report is so confidential that only a few highly placed officers are allowed to read it. They go out of office, pledged to secrecy, and their successors have to administer public affairs in ignorance of the existence of a report which, if they knew, would seriously modify their action. If that report had been published to all the world no injury resulting from the disclosure could possibly equal that which is done by concealing from the workers of to-day the facts and the opinions of the students and thinkers and experts who preceded them.

If the reports are published, it is said, some enemy may have weak places in our defences revealed to him. It is far worse that the existence of the weak places should be unknown to their natural defenders when they have been established on good evidence. Secrecy is the delight of diplomacy in every foreign office in Europe. It is unfortunately in high favour also in matters affecting naval development.

Our dockyards and arsenals are supposed to embosom secrets on which the fate of the nation depends. No foreigner must enter a dockyard without a special permission. This secrecy is made supremely ridiculous by the facts which are perfectly well known. For example, when the latest design for a ship of war, which is to be built by contract is completed at the Admiralty all the leading shipbuilders on the list of contractors are invited to send draughtsmen to make tracings of the drawings so that they may be in a position to send in tenders for building the ship. These same builders are engaged in tendering for designs prepared by themselves for foreign governments and are at liberty to embody all the newest ideas in the construction of the State Ship and her machinery in a ship for this foreign government. They may indeed hand over such a ship long before the government ship is completed.

Then as to guns and ammunition. Almost nothing new ever comes from a government arsenal. All the improvements are made by private firms like Armstrongs and Vickers; and these firms are ready to make for any customer. As a set-off to this, similar precautions are taken in France and Germany and Russia and racial distinctions are kept up as offensively as possible. As a matter of fact there are no secrets in any dockyard or arsenal at home or abroad which in the least degree justifies such unfriendly action by government officials.

The world has been enlightened lately as to how the desire to keep petty secrets, in artillery, works itself out in France, and who are the sort of people who benefit by the system—a system which creates distrust and ill feeling and encourages dishonesty.

It would benefit humanity if there were an International Bureau issuing a technical periodical giving

every supposed improvement in any department of military and naval manufacture. It would prevent great waste of money, and go far towards removing national distrusts.

In matters of naval development this has been partly accomplished by the formation of the Institution of Naval Architects and Marine Engineers. Here the foremost men in all navies coöperate. An improvement in a material, or in structural arrangement, or in the mode of investigating natural laws and their application to ships, is at once made known and openly discussed.

What the diplomatists and officials mischievously do against the world's peace, shipbuilders and engineers undo. Men like Froude and Thornycroft and Yarrow in England, like De Bussy, Bertin, Berrier-Fontaine and Normand in France, Schlick and others in Germany and Melville and Cramp in America—these men happily find for us, in coöperation, a bond of alliance.

The English Institution founded in 1860 has been a great peacemaker. It has prevented an infinite waste of money by discrediting bad schemes and plans, and by establishing sound principles and it has led to a friendly interest not only in the men who are engaged in rival navies but also in the success of their works.

Take for example the case of submarine boats. To the British Sailor the matter stands thus. To secure British lines of commerce against French cruisers in the event of war with France we must, he says, have ships enough to blockade the French naval ports and prevent their ships from getting in or out.

The French naval officer says, we cannot submit to this: We have a great mercantile marine and to be

unable to protect it is to cover ourselves with shame. Let us get out and measure swords in the open seas, we for our rights, you for yours. We cannot submit to be shut up like rats in a trap. We shall devise submarine boats capable of passing with a fair chance of success under the blockading ships and attacking them with torpedoes.

The Institution of Naval Architects says, "deeply interesting! Let us discuss these boats. How can we limit their sources of failure and increase their chances of success?"

In the end let us suppose that the submarine boat by joint effort is fairly worked out and proves its success in war. If that were so the world would be a distinct gainer and the larger the maritime interest of the nations the larger their gain because it would further discredit the big sea battalions—the large armoured ships.

The English Institution has met with success which is very gratifying to its members and it sees with pleasure the growth of a similar Institution in the United States. No country could sustain such an Institution unless its mercantile marine were strong so as to furnish a large number of associates not themselves either naval architects or engineers, but all connected in some way with maritime trade and interests.

In England it has been found that a president who is not in the profession of shipbuilding or engine building nor dependent upon the success of any particular firm or company works well.

It might be that professional or trade rivalries would introduce difficulties if another course were taken. The Institution has been very fortunate in its presidents—all of them have been Peers of the

Realm. Our experience has been that in the English peerage there is wide understanding of the injunction "He that would be greatest among you let him be the servant of all."

It is in this connexion that a few of the most notable of the workers in the promotion of naval development may be referred to. The brief obituary notices given in the *Transactions of the Institution* during the last forty years show the land marks of progress during the century.

The first of these obituary notices* was of the brothers John and Charles Wood, naval architects of Port Glasgow.

The first of their ships was the first steam-ship—the original "Comet," built on the Clyde for Bell in the year 1812. The original "Comet" was a vessel only 40 feet long, 12 feet beam, and three horse-power. In 1813 they built the next, the "Elizabeth," which was 15 feet longer (a great stride), and of eight horse-power; and in the following year they built the Clyde, 10 feet longer, and of 12 horse-power. In 1816 they built the "Glasgow," the first steamer that ventured so far to sea as the Island of Cumbrae; and when the adventurous voyagers, as they were then regarded, left upon their voyage, their friends bade them farewell, upon an enterprise which they termed "a tempting of Providence." But they got home in safety, and a few years afterwards they built the vessel called the "Talbot." In 1817 they built the first towing steamboat, which from her intended employment was named the "Tug," hence the name of a well-known useful class of steam-vessels.

The "Talbot," which the Woods built for David

* Transactions of the Institution of Naval Architects, Vol. II. pp. 142, 143, 145 and 147.

Napier in 1818 was the first mail packet that ran from Dublin to Holyhead. The next remarkable vessel of theirs was the "James Watt." It was an enormous advance in ocean steam navigation. It was designed in 1820 by Charles Wood. She had engines made by James Watt & Co., and was an enormous ship in those days. The ship before her was 60 feet long, and she was 120; the ship before her was 14 horse-power, and she was 100 horse-power. It was in those days a wonderful and enormous stride in naval architecture, and in itself formed, for ten or fifteen years, the pattern steam-ship. This "James Watt" came to London, and was for a long time a pattern vessel. Before designing her, Mr. Charles Wood suggested, as I say, the practicability of building steam vessels fit to run from London to Leith; and, in 1820, he designed the vessel just mentioned. As she was not to be propelled by masts and sails, with their leverage to depress the forebody of the vessel, but by paddles, which would impel her in the same manner as oars, she should be formed, he said, as the row galleys of the ancients were, and, therefore, her water lines were made exactly the same in the forebody as the afterbody, the midship frame being equidistant from the stem and sternpost. The cod's-head and mackerel's-tail that had been unnaturally joined together in other steamers were thus for ever separated.

John Wood built the pattern ship of the Cunard Line* and also the pattern ship of the second series of that line. The pattern of the first series was the "Arcadia," while that of the second was the Europa.

* M. Maginnis says that the Britannia was the first of this line and that she with her sisters the Arcadia, Columbia and Caledonia were built by Robert Duncan & Co. of Port Glasgow.

LIST OF STEAMERS BUILT BY MESSRS. JOHN AND CHARLES WOOD, BETWEEN 1812 AND 1845.

Date.	Name.	Length.	Breadth.	Horse-Power.	Trade.
1812	"Comet"...........	40	...	3	Glasgow and Greenock.
	"Elizabeth".......	55	11	8	Glasgow and Greenock.
	"Clyde"...........	65	12	12	Glasgow and Greenock.
	"Glasgow".........	60	16	16	Glasgow and Largs.
1817	"Tug".............	70	17	32	Went to Leith.
1815	"Caledonia".......	82	16	16	Glasgow and Greenock.
	"Argyle"..........	70	16	16	Glasgow and Greenock.
	"Lord Nelson".....	74	16	16½	Glasgow and Greenock.
	"Albion"..........	72	16	20	Glasgow and Largs.
	"Neptune".........	72	16	20	Glasgow and Largs.
	"Robert Burns"....	72	14	20	Glasgow and Greenock.
1819	"Talbot"..........	76	19	60	Went to Dublin.
	"Port Glasgow"....	74	14	16	Glasgow and Greenock.
	"Defiance"........	55	14	12	Glasgow and Greenock.
	"Marquis of Bute".	60	14	14	Glasgow and Greenock.
1821	"James Watt.......	120	24	100	Went to London.
	"Inverary Castle"..	84	17	40	Glasgow and Inverary.
	"Caledonia"........	84	14	32	Glasgow and Greenock.
	"Thane of Fife"....	82	18	40	Went to Leith.
1821	"Edinburgh Castle"	82	18	40	Went to Leith.
	"Highlander"......	60	15	20	Glasgow & Tobermory.
	"Maid of Islay"....	84	17	50	Glasgow and Islay.
	"Maid of Morven"..	65	14	30	Glasgow & Tobermory.
1821	"Largs"...........	84	17	36	Glasgow and Largs.
	"St. Catherine"...	88	16	34	Glasgow and Largs.
	"Stirling Castle"...	86	17	16	Glasgow and Arrochar.
	"Ayr".............	88	17	60	Glasgow and Ayr.
	"St. George"......	94	17	48	Glasgow and Arrochar.
1828	"Venus"...........	100	17	70	Glasgow and Kilmun.
	"Cupid"...........	40	12	10	Glasgow and Kilmun.
	"Corsair".........	120	20	100	Went to Belfast.
	"Belfast".........	108	19	60	Glasgow and Belfast.
	"Glasgow".........	120	20	100	Glasgow and Liverpool.
	"Kilmun"..........	60	12	20	Glasgow and Kilmun.
	"Locluke".........	65	13	30	Glasgow and Kilmun.
	"Castle Finn"......	70	14	30	Went to Derry.
	"Vale of Clwyd"...	90	16	50	Went to Liverpool.
	"Monro"...........	98	17	70	Went to Isle of Man.

LIST OF STEAMERS, ETC.—CONCLUDED.

Date.	Name.	Length.	Breadth.	Horse-Power.	Trade.
	"Menai"	120	20	100	Went to Wales.
	"Mona's Isle"	108	19	90	Went to Isle of Man.
	"Arran Castle"	94	16	50	Glasgow and Rothesay.
1828	"Windsor Castle"	101	16½	55	Glasgow and Rothesay.
	"Elbe"	110	17	70	Glasgow and Rothesay.
	"Queen Adelaide"	117	22	130	Went to Derry.
	"John Wood"	120	23	140	Glasgow and Liverpool.
	"Robert Napier"	128	24	180	Went to Derry.
	"Vulcan"	132	24	200	Glasgow and Liverpool.
1832	"Perth"	151	28	280	Went to Dundee.
	"Dundee"	151	28	280	Went to Dundee.
	"St. Columba"	114	20	100	Glasgow and Derry.
	"Nimrod"	99	17	70	Glasgow and Ayr.
	"Queen of the Isles"	117	22	140	Went to Isle of Man.
	"Coleraine"	112	22	140	Went to Coleraine.
	"City of Glasgow"	145	24	250	Glasgow and Liverpool.
	"Isabella Napier"	135	23	220	Went to Derry.
	"Mercury"	132	22	190	Glasgow and Dublin.
	"Sovereign"	130	24	200	Went to Leith.
1837	"Beremie"	155	29	260	Went to Bombay.
	"London"	158	28½	320	Went to Dundee.
	"Duke of Richmond"	140	24	240	Went to Leith.
	"Commodore"	167	29	350	Glasgow and Liverpool.
	"Isle of Bute"	104	16	60	Glasgow and Rothesay.
	"Maid of Bute"	105	17	70	Glasgow and Rothesay.
1837	"Maid of Arran"	94	17	60	Went to Arran.
	Ship "Annabella"	...	...	...	
	Ship "Falcon"	...	...	...	
1839	Ship "Shandon"	...	...	.	
	"Admiral," 600 tons	...	...	...	
1840	Ship "Acadia"	...	...	...	Cunard.
	S. "Mary Campbell"	...	...	...	
1841	Ship "Temmdon"	...	...	...	
1842	Ship "Acbine"	...	...	...	
	Ship "Fleetwood"	...	...	...	
1842	Ship "John Wood"	...	...	...	
1845	Ship "Europa"	...	...	...	Cunard.

The foregoing notice is from the pen of John Scott Russell.

"Mr. T. J. Ditchburn, Member of Council, set up the first Iron Shipbuilding Establishment on the Thames.*

"In 1822, when he commenced building steam vessels, the average speed did not exceed eight miles an hour; in a few years he raised it to 14 with wooden vessels. In 1844 he obtained, with an iron vessel, a speed of eighteen miles an hour in dead water at the measured mile. In the year 1845, Mr. Ditchburn was consulted by the Lords of the Admiralty as to the most proper size and form of vessel in which to convey Her Majesty from Whitehall to Woolwich. After carefully considering the subject, he proposed a certain form of vessel, and advised that she should be propelled by an Archimedean screw.

"Although experiments had been made with a propeller of this description, and some of their Lordships had been towed in their barge from Whitehall to Woolwich several years before by a small screw-propelled boat of Ericsson's, yet so little was known as to the actual merits of this method of propulsion at that time, that Mr. Ditchburn's proposal was not at first favourably received by their Lordships. But Mr. Ditchburn, like all men of real genius, had the power to make others believe in what he did, and also in his ability to carry out what he undertook.

"From the fact alone of her being the first screw steamer introduced into the Royal Navy, this little vessel is remarkable and interesting; but she had much higher claims to consideration than that, for not only was she the first screw-propelled vessel in the Royal

* Trans. I. N. A. Vol. XI.

Navy, but she was also one of the very best results of that mode of propulsion, maintaining a high character for speed, and the possession of other good qualities, for over twenty years.

"Mr. Ditchburn had long foreseen that iron was the material with which the future navies of England must be constructed, and he perseveringly pressed the Admiralty authorities of his day to make a series of experiments in iron shipbuilding for military purposes, by building ships entirely of iron with a view to get great speed, and of iron and wood for fighting purposes, and iron and wood for coast defence; but the prejudice against the use of iron in the Royal Navy was too great at that time to get his suggestions carried out, but he did get an order to build an iron man-of-war, a brig of twelve guns, with a view to her competing with a fleet of 12-gun brigs that were then constructing, some in the Royal Dockyards and others by private individuals.

"Mr. Ditchburn's brig was called the 'Recruit,' and immediately after she was completed she was commissioned and sent to Lisbon; but the trials anticipated were never made, the advocates of the wooden ships condemned her, and she was sold out of the Royal Navy, but nevertheless possesses some interest, being the first iron fighting ship that belonged to the Royal Navy of England."

REV. HENRY MOSELEY.*

"The Rev. Henry Moseley was one of the Vice-Presidents of the Institution. In 1850 he published a paper on the 'Rolling of Ships.' It contains the

* Trans. I. N. A. Vol. XIII.

most complete investigation of the oscillatory motion of a floating body that had at that time appeared. It is in this paper that the idea of the 'Dynamical Stability' of a ship was first given.

WILLIAM JOHN MACQUORN RANKINE.*

"One of the great men on the Council of the Institution was William John Macquorn Rankine, born in Edinburgh in 1820. "Rankine's most important contributions to science are in the dynamical theory of heat, in the theory of the steam engine; in that of waves in liquids, especially of sea-waves, and on the resistance and rolling of ships. He was among the earliest students in this country who were able to understand what was meant by thermodynamics. He contributed largely to the extension and settlement of the theory, and probably to a greater extent than any other person to its reduction to rules adapted to the practice of engineers; indeed he may be considered one of the founders of the science. In the study of waves in liquids, he and Mr. William Froude appear to have been the first persons who successfully worked out a possible theory of waves of finite displacement in the sea; all the previous researches were either incomplete in theory or limited to infinitesimal disturbance. Rankine and Froude, working independently of one another, appear to have been the first to arrive at a definite demonstration of the mechanical possibility of the trochoidal wave. They were not the first to suggest that the trochoid was the clue to the geometry of the sea-wave: Gerstner and Scott Russell had already done that; but it was Froude, in the *Transactions of the Institution*

* Trans. I. N. A. Vol. XIV.

of Naval Architects, and Rankine, in the *Transactions of the Royal Society*, who first gave proof that it complied with all the conditions of fluid motion, except that of the absence of molecular rotation.

"His study of the resistance of ships appears to have been suggested by an application, addressed to him and to Professor Thomson, now Lord Kelvin, by his friend, James Robert Napier, for advice as to the power necessary to propel vessels of any form. Professor Thomson then called attention to the defect in existing theories, with reference to the resistance of water to a ship's progress, from not taking account of the viscosity of the fluid. Professor Rankine stated that if the resistance outside a ship was the same as that inside a water-pipe, the power required to propel a certain vessel would be so and so, naming a power of about two-thirds what Mr. Napier had estimated to be necessary. Alluding to this, Professor Rankine wrote in August, 1858, to the *Philosophical Magazine*:—

"'In the course of last year there were communicated to me in confidence the results of a great body of experiments on the engine-power required to propel steamships of various sizes and figures at various speeds. From those results I deduced a general formula for the resistance of ships having such figures as usually occur in steamers, which, on the 23rd of December, 1857, I communicated to the owner of the experimental data; and he has since applied it to practice with complete success.'

"This circumstance no doubt led to his addressing himself to the theory of ships. With this object in view, he investigated the form and mechanical work both of sea-waves and of waves in canals, the waves which accompany ships, the loss of work consequent

on the formation of divergent waves, the stream-lines or lines of motion of water flowing past a ship, the effect of the combined oscillation of a ship and a wave, the steadying effect of keel-resistance, and many other important points of the hydraulics of a ship. On nearly all these points he did important original work, although in many of them the credit must be shared among him and others who were working abreast of him—notably Sir W. Thomson (Lord Kelvin) and Mr. W. Froude. He also studied the question of propulsion, and placed its theory on a sound basis. This branch of knowledge owes more to Rankine than to any other writer."

MR. JOHN SCOTT RUSSELL.*

"Mr. John Scott Russell was the moving spirit in the formation of the Institution of Naval Architects and Marine Engineers. It may be said that he was its founder. Though he had intended to become an engineer, he does not appear in the outset of his career to have found an opening in the profession. He settled down in Edinburgh when he was eighteen or nineteen years of age, and in conjunction with one of his friends, founded a preparatory school for the University, called the South Academy, which exists at the present day. He was encouraged shortly afterwards to commence science classes at the Mechanics' Institute, at Leith, and at the University of Edinburgh, by the example of his old professor of geometry at St. Andrew's, who had settled down at Edinburgh, and whose classes were well attended. The original method with which Scott Russell treated scientific questions, and his excessive force and clear-

* Trans. I. N. A. Vol. XXIII.

ness of exposition, rapidly produced a deep impression on the students at the University; his lecture-room was soon filled, and when he commenced his second course, he had emptied the classes of his rival and former master. He continued at Edinburgh for some years, lecturing at the University and carrying out experiments on steam-engines and boilers. In 1832, Sir John Leslie, the Professor of Natural Philosophy, died, and so great was Mr. Scott Russell's reputation and popularity as a teacher, that he was appointed, when only twenty-four years of age, to temporarily fill the vacancy pending the election of a new professor. On the understanding that Brewster was to be elected, Mr. Scott Russell declined to compete for the post, but when it was known that Forbes was a candidate, and had a good chance of being elected, many of Mr. Russell's friends strongly urged him to offer himself. This, however, he declined to do, and after Professor Forbes' election, Mr. Scott Russell's connection with Edinburgh University seems to have terminated, and he henceforth devoted himself with greater attention to practical engineering and experimental research.

"In the year 1833, Mr. Scott Russell was consulted by the directors of a Scotch Canal Company as to the practicability of adopting steam navigation on canals. His reply was to the effect that neither he nor anybody else could give an opinion of any value on the subject, but that he would gladly undertake experiments, if the directors would authorise him to do so, and would place a portion of the canal at his disposal. They assented, and in this manner was commenced the famous series of experiments on the nature of waves, and on the resistance which water opposes to the motion of floating bodies, in connection with

which Mr.Russell's name is so well known. He read his first paper on the subject before the British Association in 1834. This he followed up with another paper in the following year, and in 1836, at the Bristol meeting of the Association, he and Sir John Robinson, Secretary of the Royal Society of Edinburgh, were appointed members of a committee to investigate the whole subject of waves. The report was drawn up by Mr. Scott Russell, and was presented to the Association in 1837. It contains the records of a variety of observations on ordinary waves of the sea, tidal waves, and waves generated in confined channels, together with the conclusions drawn from the observations.

"In this report Mr. Russell minutely describes the Wave of Translation, which he discovered in 1834. At the same meeting of the Association he read two papers of great practical interest, viz. one on the *Mechanism of Waves* in relation to the improvements of steam navigation, and the other on *Improvements in Tidal Rivers*. In the first of these papers he announced for the first time, it is believed, his wave-line system of shaping vessels.

"The first vessel on the wave system was built in 1835; it was called the 'Wave.' It was followed in 1836 by the 'Scott Russell,' the 'Flambeau,' and 'Fire King.' At this time Mr. Russell was employed as manager of the shipbuilding yard which is now owned by Messrs. Caird & Co. While in this employment, he succeeded in having his system introduced in the construction of the new fleet of the Royal Mail Company, and four of the largest of their vessels at that time, viz. the 'Teviot,' the 'Tay,' the 'Clyde,' and the 'Tweed,' were designed and built by himself.

"In 1844, Mr. Russell removed to London, and took an active part in the management of the Society of Arts, which was then not in a flourishing condition. By his energy he succeeded in resuscitating it. He was appointed joint-secretary to the Society, in 1845, and subsequently became sole secretary. During his secretaryship the Society obtained a Royal Charter of Incorporation, and the series of national exhibitions was commenced, which eventually led to the holding of the first great International Exhibition of 1851. The late Prince Consort bore testimony to the value of Mr. Russell's labours on behalf of the Exhibition, in a letter in which he stated that it was 'by dint of Mr. Scott Russell's tact, judgment, penetration, resource and courage that obstacles vanished and intrigues were unmasked.'

"Mr. Scott Russell was for many years well known as a shipbuilder on the Thames, and introduced several important improvements in the construction of iron vessels. He was the first to plate iron ships with alternate 'in and out strakes.' He also invented and developed the longitudinal system of building, and was the first to introduce cellular double bottoms. Although this system of construction has not been followed much in the mercantile marine, a modification of it has been employed by the Admiralty in the construction of men-of-war, ever since the first introduction of iron-clad shipbuilding into the Royal Navy. The largest and most famous ship which Mr. Scott Russell constructed in the Thames was the 'Great Eastern.' She embodied all the principal features of shape and construction for which Mr. Scott Russell contended; viz. the wave-line form, longitudinal framing, cellular double bottom, iron decks, and numerous complete and partial transverse bulkheads."

DR. JOSEPH WOOLLEY, M. A.*

"Dr. Joseph Woolley, M. A., was one of the original founders of the Institution, and one of its most active supporters.

"In the year 1848 he commenced that part of his career which was of most interest to the members of the Institution, for he was then appointed Principal of the School of Naval Construction at Portsmouth Dockyard, and retained this post till the school was abolished by the Admiralty in 1853. During the short time that this establishment was in existence Dr. Woolley numbered amongst his pupils many of the best-known naval architects of the day, including Sir Edward Reed, Sir Nathaniel Barnaby, Mr. Barnes, Mr. Crossland, and Mr. Morgan.

"Dr. Woolley's high mathematical attainments, and the interest which he took in applying his scientific knowledge to the solution of many of the intricate problems connected with ship design and construction, enabled him to render the most valuable services to the science of naval architecture, and much of the progress which has taken place during the past forty years must be attributed to his labours, both as a teacher and as an investigator. His appointment to the School of Naval Construction put him in a position to learn how very backward the theory of naval architecture was in this country, and he earnestly set to work to remedy the then existing state of things, with a success to which the Transactions of this Institution bear continuous testimony.

"When at Portsmouth he wrote an able treatise on *Descriptive Geometry*, a subject which was then almost unknown in Great Britain. He also arranged

*Trans. I. N. A. Vol. XXX.

a complete course of studies for the use of his students, embracing every subject bearing on naval architecture. He afterwards wrote a second treatise on the application of descriptive geometry to the problems of naval construction, but the manuscript was only just completed when the Portsmouth School was abolished, and the book unfortunately was never published. On vacating his post at Portsmouth, Dr. Woolley was appointed Admiralty Inspector of Schools, and in 1858 he was nominated one of H. M. Inspectors of Schools. In these capacities he rendered important services in organising education for the navy.

"One of the earliest efforts of the Institution was directed towards influencing the government to re-establish a technical School for Naval Constructors, and when, in 1864, the Royal School of Naval Architecture and Marine Engineering was founded, under the joint auspices of the Admiralty and the Committee of Council on Education, Dr. Woolley was very rightly appointed Inspector-General and Director of Studies. He held this post under somewhat modified conditions till, in 1873, the School was merged in the Royal Naval College at Greenwich.

"Shortly after the loss of H. M. S. 'Captain,' in 1870, Dr. Woolley was nominated by the Admiralty a member of Lord Dufferin's Committee, which was appointed to consider many vexed questions relating to the design of ships of war. This committee, in their very able report, threw much light on the difficult subjects which they were appointed to consider.

"When the qualities of H. M. S. 'Inflexible' were called in question, the Admiralty appointed a committee, of which Admiral Sir James Hope was Chairman, to investigate the subject. Dr. Woolley was one

of the members of this committee, and his participation in its labours was almost the last public duty in connection with Naval Architecture which he was called on to perform.

"Dr. Woolley invented a very elegant method of ascertaining the volume of the displacement of a ship or other floating body."

MR. JOHN PENN.*

"Another notable member of Council was Mr. John Penn, of Greenwich. "Though the oscillating engine was not invented by Mr. Penn, he early recognised its great advantages, and applied it with improvements of his own to the river steamer 'Endeavour,' which ran between London and Richmond. The improvements which he effected were so great than in 1844 he was employed by the Admiralty to supply new engines of the oscillating type to the Admiralty yacht 'Black Eagle.' This task he accomplished with great success. His new engines and boilers occupied only the same space as the old ones, and developed double the power. In consequence these engines came into general use, and Mr. Penn afterwards received orders to engine the Royal yacht 'Victoria and Albert' and the 'Great Britain' steamship.

"His success in improving the screw-engine was perhaps even more marked. One of the great objects to be accomplished in order that screw-propellers might be usefully applied to men-of-war was to keep the engines well below the water-line in a position of comparative security against the effects of shot and shell. One of the solutions of this problem was the introduction of the well-known type of trunk-engines,

*Trans. I. N. A. Vol. XX.

in which the intermediate gearing was done away with, and the piston coupled direct to the crank without the intervention of a piston-rod, an arrangement which enabled the engines to be kept low and compact. The first vessels fitted with these engines were the 'Arrogant' and 'Encounter' in the year 1847, and these proved so successful that the type came into general use for men-of-war, and before Mr. Penn's death, his firm had fitted up no fewer than 230 vessels with trunk-engines of sizes, varying from 20 horse-power for small gunboats, to 8,832 horse-power, which latter power was developed by the engines of H. M. S. 'Neptune,' and is the greatest power ever attained by a single pair of cylinders. Mr. Penn also paid great attention to the subject of increasing the piston speeds of screw-engines, and by careful design and great perfection in workmanship he was enabled to make improvements in this direction, which were attended by large savings in the weights of the machinery and the spaces occupied by it.

"Another great service which Mr. Penn rendered to the cause of screw-propulsion was the application of lignum vitæ to the sea-bearings of screw shafts. For a long time the success of the screw as a substitute for paddle-wheels was rendered doubtful by the rapid wear of every description of metal bearing. After a series of experiments had been carried out for him by Mr. Francis Pettit Smith, Mr. Penn patented in 1854 the use of lignum vitæ for this purpose, and applied the invention with the most complete success, in the first instance to H. M. corvette 'Malacca,' for, previously, this vessel had been wearing away her outer screw shaft bearings at a rate of $3\frac{1}{2}$ ounces per hour, but after the introduction of wooden bearings she was enabled to steam 15,000 miles, the wear at the end of this voyage being scarcely appreciable."

SIR WILLIAM SIEMENS.*

The obituary notice of this distinguished man says: "Charles William Siemens was born in Hanover, in 1823, and had the advantage of receiving in his early youth a technical education of a kind which was not at that period to be obtained in this country. Of an adventurous disposition, the young Siemens determined to leave his native land and try his fortune in other countries. He landed at the East end of London in 1843, 'with,' to use his own words, 'only a few pounds in my pocket, and without friends, but with an ardent confidence of ultimate success within my breast.' Thanks to the kindness of Mr. Elkington and Mr. (afterwards Sir Josiah) Mason, he found his first opportunity in this country, and succeeded in turning it to good account, and was enabled to return to his own country and to his mechanical engineering, again using his own words, 'a comparative Crœsus.' He, however, did not remain absent long, but returned shortly afterwards to settle in this country for good. His career in the land of his adoption has been one unbroken series of successes. It would be impossible, within the limits of this short notice, to give an account of all the inventions which have been made or matured by Sir William Siemens during the last forty years. The greater portion of them have nothing to do with the science of naval architecture. He was eminent not only as a mechanical engineer, but as an electrician, a chemist, and metallurgist, and it was in the latter capacity that he was enabled to exercise the most enduring influence on shipbuilding.

"In the year 1875, Mr. Barnaby, in a paper read be-

*Trans. I. N. A. Vol. XXV.

fore this Institution, made his memorable challenge to the steel-makers of Great Britain to produce for the use of the Admiralty a quality of steel which should satisfy ship-builders, which should possess certain well-defined characteristics which he was careful to specify, and which should enable the Constructive Department at the Admiralty to build vessels of steel throughout with confidence. Dr. Siemens at once accepted the challenge, and the metal produced by the Siemens open-hearth process was proved to possess all the qualities which were asked for, and it was accordingly used as the material for the construction of the hulls of the 'Iris' and 'Mercury.' So satisfactory has it been found that this quality of steel and Bessemer steel are now in extensive use in the Royal dockyards for the construction of the hulls and boilers of ships of war, at a cost far below that of the iron of 1875, and its use is every day extending in the mercantile marine."

VICE-ADMIRAL PARIS OF THE FRENCH NAVY.*

He was for many years an Associate of the Institution. "He entered the French Navy as midshipman in 1822, commanded a frigate in 1840, became a post-captain in 1846, in which capacity he took part in the Crimean war, and was especially distinguished in the attack on Kinburn. He thrice circumnavigated the globe, the first time as midshipman on board the 'Astrolabe.' He was promoted to the rank of rear-admiral in 1858, and to vice-admiral in 1864. When steam propulsion for war-ships first came into notice, he obtained permission to go to England to study

*Trans. I. N. A. Vol. XXXIV.

the construction of the marine engine, and he passed three months at the factory of William Fawcett; he was afterwards largely instrumental in causing the introduction of steam propulsion into the French Navy. He was the author of several works on professional subjects. Among the first was his *Dictionnaire de la Marine à Vapeur;* then followed his *Manuel du Méchanicien*, his *Catéchisme du Méchanicien*, and a treatise on the screw propeller. In 1863 he was appointed a *Membre de l' Institut.* For some time he was at the head of the Hydrographic Service of the French Admiralty, and he was also a Member of the *Bureau des Longitudes.* After his retirement from active service, he was appointed Conservator of the Marine Museum at the Louvre. He found the Museum in a very indifferent state, and left it the most perfect in the world. He himself contributed largely to its collections, for he was a most expert and artistic draughtsman, and during the last twenty years of his life he drew no less than three hundred plates illustrating old types of ships, many of which would have been lost for ever but for his labours. He published these plates in a beautiful work entitled *Souvenirs de Marine Conservés.* He arranged with the Academy of Science to continue the work after his death. He was also an expert modeller, although he had lost his left arm. The large model of the Suez Canal at the Louvre is entirely the work of his hand. Vice-Admiral Paris was elected an Associate of the Institution in the year 1862, and he was elected an Honorary Associate in 1885. He contributed six Papers to the Transactions, the latest being a *Description of an Instrument to Analyse Rolling*, published in 1886."

WILLIAM FROUDE.*

"William Froude, Vice-President of the Institution of Naval Architects, was born in 1810, and was a son of Archdeacon Froude, of Darlington, Totnes. He was a King's Scholar at Westminster, and went thence to Oriel College, Oxford, where he was the pupil of his brother, Hurrell Froude, and of John Henry Newman. He would dwell in after years with gratitude on the sound training in mathematics which he received from his brother, and which resulted in his obtaining a first class in the Mathematical Class List.

"On leaving Oxford, Mr. Froude adopted the profession of a civil engineer, and became a pupil of W. H. R. Palmer, and in 1838 an assistant of Mr. Brunel, under whom he was engaged on the works of the Bristol and Exeter Railway, and in other engineering work. Mr. Froude's regular professional work ceased in 1846, when he retired on account of his father's failing health; but he continued to occupy himself in scientific investigations of a high order, as for example, the discharge of elastic fluids under pressure, and the resistance experienced by a plane moving obliquely in a fluid. Mr. Froude also gave his assistance in the solution of various practical questions in the district in which he lived.

"His intimate friendship with Mr. Brunel led him back at times to take part in engineering work, and on the occasion of the launch of the 'Great Eastern' (1857) Mr. Froude conducted a series of experiments on friction, and on the behaviour of the ship herself.

"It was also in reference to the 'Great Eastern' that, in 1856, at Mr. Brunel's request, Mr. Froude

*Trans. I. N. A. Vol. XX.

undertook the inquiry into the rolling of ships, which will always be connected with his name.

"Mr. Froude grasped the true elementary nature of the action of wave-water on a floating body, and of the effect of successive waves on a ship exposed to their action. As an essential stepping-stone to progress in the inquiry, he established on thoroughly sound principles the mechanical possibility of that form of motion known as the trochoidal sea-wave, a subject which has been discussed by other writers. The leading principles of his views he exemplified by experiment, and at an early meeting of this Institution (1861) he brought forward the leading propositions with regard to the rolling of ships, which form the groundwork of the now established theory on the subject. The building up of the theoretical structure thus started was a task which he rapidly proceeded with; he appreciated and applied in their correct bearing on the subject the several causes modifying the application of the elementary principles, and he explained his views in papers contributed to this Institution.

"Having brought the inquiry to this stage Mr. Froude was fortunate in having an opportunity of investigating the subject experimentally. By still-water rolling experiments on a large number of Her Majesty's Ships (1871 to 1876) he obtained by self-recording apparatus a definite measure of the resisting force offered by the water to the rolling motion of a ship in still water. The results when analysed he reduced to mathematical expressions which represented the action of this force. He also measured the rolling at sea of the 'Comet' gunboat (1872) and of the 'Greyhound' (1872), using for that purpose a simple arrangement of a pointer worked by

an observer, combined with a self-recording pendulum.

"Mr. Froude, appreciating the effect of 'resistance' in checking rolling, had from an early date recommended the extended use of bilge-keels as a remedy. They had been applied with much success to the Indian troop-ships, and as a member of the Committee on Designs, Mr. Froude had made instructive experiments with large models of the 'Devastation' fitted with bilge-keels of various sizes (1871). Further, to test the importance of bilge-keels, comparative trials were made off Plymouth (1872) of two ships of the same class, the one ('Greyhound') with bilge-keels, and the other ('Perseus') without; the results have been published.

"When the 'Devastation' made her sea-going trials Mr. Froude accompanied the vessel in trials off Queenstown and off Bantry (1873), and on her first voyage to the Mediterranean (1875). Though seas of the character most suitable for experiment were not found on either occasion, she met with a very heavy sea off Bantry, and with a long and low swell off Lisbon, which supplied valuable experimental data.

"In the 'Greyhound,' when tried off Plymouth and subsequently in the 'Devastation,' Mr. Froude used an instrument he had devised, in which a heavy, delicately-hung fly-wheel which took the place of the pointer, and a suitably placed pendulum, recorded their behaviour on a diagram, and not only measured the ship's oscillation, but also measured, as a differential phenomenon, the mean wave acting upon the ship, with a degree of exactness exceeding that with which it had hitherto been possible to ascertain the profile of the surface wave of the sea.

"As a member of the 'Inflexible' Committee, Mr. Froude had the opportunity of testing experimentally on a large model the extent to which loose water in a ship may operate to check rolling, a point which he had for some time thought of much importance, and which had been one of the features of the design of that ship. The quelling effect was most marked.

"Aided by these experimental researches, Mr. Froude had brought to definite terms the quantitative determination of the leading features in the theory of rolling, and may in fact be considered to have established not only the leading true principles, but to have put these into a workable shape. Not, indeed, that he considered the inquiry exhausted, for at his death he had in preparation at the experiment tank at Torquay means for prosecuting further important branches of the investigations, by means of experiments on models floating in artificially-formed waves. The same apparatus was also intended for the investigation of the cognate subject of pitching, on which Mr. Froude had made observations in the 'Devastation' off Bantry, and on which he had made valuable reports to the Admiralty. Mr. Froude prepared a memorandum for the guidance of officers of the Royal Navy in making the observations of ocean waves which are ordered to accompany observations of rolling. A mass of valuable data is thus being acquired.

"The value of Mr. Froude's labours on the subject of rolling is probably exceeded in a commercial, if not in a scientific, point of view by that of his work in regard to the resistance and propulsion of ships. Being an able yachtsman, and also experienced in steamship trials, the problem of the resistance of the water to a vessel moving through it had been amply

brought before his notice; and when he had the opportunity he endeavoured to feel his way towards a consideration of the subject by experiments with models. While thus engaged, he set himself to consider, and succeeded in arriving at the law of comparison by which a ship's resistance may be deduced from that of her model. He exhibited the general correctness of the proposition by conclusive experiments.

"Mr. E. J. Reed, then Chief Constructor of the Navy, saw the importance of encouraging a method of thus economically ascertaining the resistance of ships; and having visited Mr. Froude, and seen the experimental results, he requested Mr. Froude to put into a definite proposal his willingness to conduct a series of experiments for the Admiralty. Mr. Froude's offer was accepted at a later period, not without some public questioning as to the comparative utility of small-scale and full-sized experiments. An experimental tank with its machinery was erected near Mr. Froude's house, at Chelston Cross, Torquay, and most valuable work has been there carried on. All the recent ships of the Royal Navy have been subjected in model to these experiments. Several kindred experiments were also tried, and a series of experiments on form has been in progress, with a view to obtaining generally applicable principles. Also, as a preliminary to the other work, a series of experiments on surface friction were tried.

"In 1871, on the recommendation of the Committee on Designs, an important experiment was tried under Mr. Froude's superintendence. A full-sized ship, the 'Greyhound,' was towed at various speeds and the tow-rope strain accurately measured. The

results verified the law of comparison on which the utility of the model experiments chiefly depends.

"The problems of resistance naturally lead to those of propulsion, as many of Mr. Froude's papers will testify, and in this Mr. Froude has rendered important service by pointing out, measuring and dividing into its several elements the waste of power connected with the use of propellers, and of the screw propeller especially. The above-mentioned 'Greyhound' towing trial, compared with the results of her steam trials, marked sufficiently the magnitude of the waste. One important element of this waste, on which Mr. Froude had made some experiments on a small scale, is the prejudicial action of the screw propeller when placed too near the stern of the ship, where it wastes power by diminishing the water pressure at the stern of the vessel. The action of screw propellers formed an important part of the investigations at Torquay, and the amount of the augmentation of resistance caused by the action of the propeller behind various forms of ships has been determined with considerable exactness. The surprising results of the early steam trials of H. M. S. 'Iris' led Mr. Froude's attention more closely than before to the action of the propeller itself, and his paper on the *Elementary Relation between Pitch, Slip, and Propulsive Efficiency*, read at the Institution, was the last of his many contributions to our *Transactions.*

"For the investigation of the propulsion of ships, it being of the greatest importance to obtain accurate and detailed records of the phenomena attending their performance under steam, Mr. Froude had for some time past turned his attention to measured mile trials. His paper on Mr. Denny's 'progressive speed trials'

was one of the fruits of this. A number of elaborate observations were made by Mr. Froude during the measured mile trials of the 'Iris,' resulting in a large body of interesting information, and his investigations on this subject will probably lead to a great increase in the practical and scientific value of steam trials.

"To determine the power wasted in marine engines, and so to estimate the proportion of the whole indicated horse-power actually delivered to the screw propeller, Mr. Froude, at the request of the Admiralty, designed and superintended the construction of a dynamometer to be capable of measuring 2,000 horse-power.

"He also, though rarely, gave popular explanations of the subjects he was dealing with. In his opening address as President of the Mechanical Section of the British Association at Bristol in 1875, he gave an intelligible exposition of the doctrine of stream-lines as far as it effects the fundamental principles of the resistance of ships. This address he afterwards delivered as a lecture at the Royal Institution.

"Mr. Froude was an able workman; with his own hands he executed many most accurate pieces of work, and was thus apt at truly testing the workmanship of others. His mechanical skill is shown by the design and details of the many beautiful machines he contrived for his various investigations. The model cutting machinery; the happy idea, the result of thoughtful consideration, of using hard paraffin for the models; the highly sensitive governors used in the various instruments; the resistance-recording apparatus for the model experiments; the large machine for measuring the tow-rope strain in the full-sized ship trials; the rolling recording instrument; and, lastly,

the large screw-engine dynamometer,—all bear witness to his mechanical skill. The principle of the last-mentioned machine especially was the legitimate outcome of a correctly followed search for a means to the desired end.

"Mr. Froude went out to the Cape in H. M. S. 'Boadicea,' in December, 1878, for a holiday, and was on the point of starting for England, refreshed in mind and body, when he was taken ill with dysentery. He died on May 4. He was followed to his grave in the Navy Cemetery, Simons Town, by men and officers of Her Majesty's ships, as was fitting for one who had rendered such great services to the country in relation to the Royal Navy. His death is a heavy blow to science, and more especially to that branch of science with which the Institution is concerned.

"It is understood that in the official letter of condolence sent by the Lords Commissioners of the Admiralty to Mr. Froude's family, they expressed strongly their sense of the services rendered 'to the Navy and to the Country, in making his great abilities, knowledge, and powers of observation available for the improvement of the designs of ships, without reward or any other acknowledgment than the grateful thanks of successive Boards of Admiralty.' The value of his services to naval architecture has been as fully recognized abroad, for it was in the interests of a general progress in the knowledge of the laws of Nature that he laboured."

SIR EDWARD HARLAND.*

"In the year 1852, after visiting the Great Exhibi-

*Trans. I. N. A. Vol. XXXVII.

tion in London, Edward Harland went to Glasgow, and was engaged as a journeyman by Messrs. Thomson, of Clyde Bank, who were at that time engine builders; but shortly afterwards the firm commenced ship-building, and young Harland very soon became chief ships' draughtsman. He did not, however, remain long with Messrs. Thomson; for, in 1853, he was appointed manager in the firm of Thomas Toward, on the Tyne.

"In the following year he replied to an advertisement for a manager from Messrs. Robert Hickson & Co., of Queen's Island, Belfast, and obtained the post, but the firm got into difficulties and had to make an arrangement with its creditors. Business was recommenced, and, shortly afterwards, with the assistance of Mr. Schwabe, of Liverpool, Mr. Harland bought the works, and soon afterwards took into partnership Mr. Wolff, a nephew of Mr. Schwabe, who had served his apprenticeship as an engineer with Messrs. Joseph Whitworth & Co., of Manchester. Thus was founded the famous firm of Harland & Wolff.

"Amongst the earliest orders received by the new firm was one for three iron screw steamers, from Messrs. J. Bibby, of Liverpool. These vessels were 270 feet long, by 34 feet beam. In 1862, when Messrs. Bibby placed a further order with the firm, Mr. Harland proposed that the new vessels should have a greater length, both absolutely, and relatively to their beam, and the 'Grecian' and 'Italian' were built of the same beam as the former trio, but 310 feet long. Longitudinal strength was obtained by making the upper decks of iron, a system then in its infancy, but which was originally introduced in the 'Great Eastern.' In spite of many prognostications of failure these vessels turned out entirely success-

ful, and three more were ordered of the same beam, but 20 feet longer. Sir Edward Harland was always a strong advocate down to the end of his life of long ships. He had, however, to encounter a great deal of opposition to his ideas. These vessels were nicknamed 'Bibby's Coffins,' by people who prophesied that they would never return to port; but they did nothing to justify the prophets of evil. On the contrary they proved highly successful, and many further orders were placed with the firm by Messrs. Bibby, each new vessel showing an increase in length over its predecessor.

"Perhaps the vessels with which the names of Messrs. Harland and Wolff are most identified are those of the Oceanic Steam Navigation, commonly called the White Star Line. When this company was founded by Messrs. Ismay and Imrie, of Liverpool, six new steamers were ordered from Messrs. Harland and Wolff. They were to be capable of carrying heavy cargo as well as a full complement of passengers, between Liverpool and New York. The first of these vessels, named the 'Oceanic,' was launched in August, 1870, and marked a new departure in the history of trans-atlantic navigation. Every new improvement that could contribute either to the efficiency of the vessel or to the comfort of the passengers was embodied in her. She was 400 feet long on the keel, by 41 feet wide; of 3,807 tons gross, and 2,000 I. H. P. She was the first transatlantic liner fitted with vertical tandem compound engines. This was in the days of the infancy of the compound marine engine. The first-class passenger accommodation was placed amidships and the saloon extended to the whole width of the ship. Over the saloon was a commodious promenade deck; gas, for

lighting purposes, was manufactured on board, and electric bells fitted for the first time on board a passenger steamer. As is well known this vessel proved a very great success. She was followed by the 'Britannic' and 'Germanic,' which were celebrated ships in their day, and these were succeeded by a number of other steamers for the same line, each being an improvment on its predecessor, till the culminating point was reached in the 'Majestic' and 'Teutonic,' launched in 1889, being 582 feet long, by 57 feet 8 inches beam, of 10,000 tons gross, and 18,000 I. H. P. developed in two sets of triple-expansion engines.

"The White Star Line and Messrs. Harland and Wolff were not famous for great passenger steamers alone. Reference should also be made to their splendid cargo and live stock steamers. Amongst these may be mentioned the 'Nomadic,' 'Tauric,' and 'Bovic,' built in 1891 and 1892, the 'Gothic,' built for the New Zealand trade in 1893, and the 'Civic' and 'Georgic' also for the New Zealand trade, which are at present the largest cargo steamers afloat, being of over 10,000 tons gross measurement.

The firm commenced engine-building in 1880, and in 1884 constructed as much as 41,800 I. H. P. The works, which occupied two acres when taken over by Mr. Harland, covered at the time of his death an area of eighty acres."

MR. THOMAS ISMAY.*

"Thomas Ismay was born in 1837, at Maryport, where his father was a shipbuilder and shipowner. He was apprenticed, at the age of 16, to Messrs.

* Trans. I. N. A. Vol. XLII.

Imrie & Tomlinson, shipowners, of Liverpool. With his fellow-apprentice, Mr. William Imrie, he afterwards started the well-known firm of Ismay, Imrie & Co. In 1867, he acquired the White Star Line of Australian clippers, and in the following year, in conjunction with Mr. William Imrie, he founded the Oceanic Steamship Company, which is popularly known as the White Star Line. In 1870, this company entered into competition for the Atlantic trade with the S. S. 'Oceanic,' built for it by Messrs. Harland & Wolff, between whom and Mr. Ismay's firm there always existed the most intimate business relations. The 'Oceanic' marked a new departure in the history of trans-atlantic navigation. She was followed by the 'Britannic' and 'Germanic,' and by many other famous vessels of continuously increasing size and comfort, culminating in the vessel 'Oceanic.' The company also built many cargo boats of very large size, including the 'Georgic,' of 10,077 tons registered. Thanks to the attention which Mr. Ismay devoted to the comfort and safety of its passengers, the White Star Line rapidly became a favorite one with the travelling public, on both sides of the Atlantic, and has had a most prosperous career.

"Mr. Ismay retired from the firm of Ismay, Imrie & Co., in 1892. He still, however, retained the chairmanship of the White Star Line, the fleet of which amounted in the aggregate, last year, to 164,-000 tons."

MR. WILLIAM DENNY.*

"William Denny, of Dumbarton, was another prom-

*Trans. I. N. A. Vol. XXVIII.

inent member of the Institution. Mr. Denny's firm was amongst the earliest to recognize and to take advantage of the qualities of mild steel for shipbuilding purposes. In the year 1876 they built their first steamer of Bessemer steel; viz. the 'Taepirg,' a light-draught paddle-boat, constructed for the Irrawaddy Flotilla Company. Two years afterwards they built another steamer for the same company, this time of Siemens steel, and in the year following they constructed the 'Rotomahana,' for the Union Steamship Company of New Zealand, which was the first ocean-going merchant steamer built of mild steel.

"In the year 1883 the attention of naval architects was concentrated on the subject of the stability of ships. The natural result was a large number of papers on the calculation of stability in the *Transactions* of this Institution for the year 1884. One of the most important of these was contributed by Mr. William Denny, under the title of 'Cross Curves of Stability, their Uses and a Method of Constructing Them, Obviating the Necessity for the Usual Correction for the Differences of the Wedges of Immersion and Emersion.' Shorty after the 'Daphne' inquiry, it occurred to Mr. Denny that, as stability curves were required for at least four draughts of each steamer, it would be well if some method of obtaining these curves could be found which would facilitate their construction. The actual methods adopted were devised by two gentlemen on the staff of the firm, and are described in the paper. This was the last contribution of Mr. Denny to the *Transactions* of the Institution.

"Mr. Denny's influence on the progress of naval architecture was by no means limited to the papers read before this and other scientific institutions. He

was remarkable, as a business man and a ship-builder, for his faith in scientific methods, and for his eagerness in endeavouring to apply the teachings of science to everyday commercial practice. His views on this subject cannot be better explained than by quoting his remarks in the discussion on two papers read by members of his staff, published in Vol. XXVI. of the *Transactions*: 'What I claim, however, is that my firm have laid it down as a fixed policy that no theory shall be put forward in their office which is not immediately linked to practice. Such a policy is of value, because theory is continually rendered more fruitful by embracing practice, and practice is kept from degenerating into mere rule of thumb by being wedded to theory. I believe in such matters we are wiser and more sensible in the present day than we were in the past.'

"It was in strict accordance with these views that he determined that his firm should have an experimental tank for the purpose of trying model experiments, similar to that first set up at Torquay by the late Mr. W. Froude for the Admiralty."

SIR JAMES WRIGHT.*

"Sir James Wright was one of the Vice-Presidents of the Institution. He was for many years Engineer-in-Chief of the British navy. Sir James Wright's tenure of office corresponded with a period of incessant change and improvement in steam machinery for the introduction of which into the British navy he was responsible. When first he was appointed assistant to the Engineer-in-Chief, steam pressures averaged about 20 lbs. to the square inch. Box-

*Trans. I. N. A. Vol. XLI.

boilers were used, and the engines were fitted with jet condensers. Gradually pressures rose, the box-boiler gave way to the cylindrical type, the engines were made compound, and surface condensers substituted for those of the simple jet type. Engines and screw propellers in war-ships were duplicated. The introduction of triple-expansion engines enabled very high pressures of steam to be used advantageously, and involved great increases in the scantlings of cylindrical boilers. It was in Sir James Wright's time also that forced draught was introduced into the navy, and during the last few years of his service torpedo boats with locomotive boilers were adopted."

LORD BRASSEY.

"The name of Lord Brassey stands high in this mutual effort towards naval progress. His *Naval Annual* has brought to all the ship-builders and engineers of the world the most valuable information, not by way of disclosing secrets, for he does not do that, but by comparing ideas and plans from all navies and throwing light upon difficult problems for the common benefit. It is largely due to him that England has been able to hold aloft the lamp of progress in the naval development of the last part of the century."

CHAPTER XV.

FIFTEEN YEARS OF PROGRESS IN THE UNITED STATES NAVY.

Fifteen years ago I visited Roach's shipyard and inspected, by the courtesy of Mr. Secretary Whitney and Chief-Constructor Theodore Wilson, the new cruisers "Boston" and "Chicago."

At an earlier period I had been the examiner in naval architecture at Greenwich of the men who were already busy in designing the new navy. I had some talk at Chicago with business men as to the projected scheme for the formation of a great navy. There was not much enthusiasm for it there. But there was a strong naval sentiment apparent at Washington and a fine group of trained seamen ready to put their hearts into the work.

They were not hampered by being obliged to go through the slow beginnings of things. They had steel to begin with as a building material; fast running engines for propulsion; good types of boilers, steel armour and breech-loading guns.

They commenced, with the best wishes of England, on the high rungs of the ladder. They had just secured the design of the "Texas" by competition, and I afterwards saw the detailed plans in course of preparation for building her in an English shipyard. By these drawings and plans she was eventually built at Norfolk Navy Yard.

If she is compared with the ships designed in the United States subsequently the immense advance made by the Naval Architects of the States is striking. The "Oregon," "Kearsarge" and "Iowa" classes, the "Charleston" and "Georgia" classes, and armoured cruisers "New York" and the rest make up a fine navy.

There are now on the list for the United States 22 ships of over 10,000 tons displacement. Several of these are of 22 knots an hour speed and are armed with 12-in. and 13-in. guns of the most powerful type.

The sizes of the ships have gone steadily up.

Date.	Name.	Displacement. Tons.
1890..	"Indiana"	10,200
1892..	"Iowa"	11,340
1895..	"Kentucky"	11,540
1896..	"Alabama"	11,565
1898..	"Maine" (new)	12,400
1899..	"Georgia" (sheathed)	15,320
1900..	"Virginia" (unsheathed)	14,950

I recently sat with a large assembly of British and Foreign ship-builders, engineers and naval officers when Professor Biles, one of the Vice-Presidents of the Institution of Naval Architects, set before them particulars of the great work which had been done in the United States.

I append here two of the sets of tables prepared by him for the information of European sailors and ship-builders.

ARMOURED CRUISERS.

	California. Nebraska. West Virginia (sheathed).	Maryland. Colorado. South Dakota.	St. Louis. Milwaukee. Charleston.	Denver. Des Moines. Tacoma. Chattanooga. Galveston. Cleveland (sheathed).
Class	1st class armoured cruiser.	Armoured cruiser.	1st class protected cruiser.	Protected cruiser.
Date of authorisation	1899	1900	1900	1899
Average contract cost (exclusive of armour)	$3,858,300	$3,768,000	$2,743,700	$1,049,250
Length L. W. L.	502 ft. 0 in.	502 ft. 0 in.	424 ft. 0 in.	292 ft. 0 in.
Breadth (extreme)	70 ft. 0 in.	69 ft. 6 in.	66 ft. 0 in.	44 ft. 0 in.
Freeboard amidships	18 ft. 0 in.	18 ft. 0 in.	17 ft. 8 in.	15 ft. 9 in.
Mean draught	24 ft. 6 in.	24 ft. 6 in.	23 ft. 6 in.	15 ft. 9 in.
Displacement (tons)	13,800	13,400	9,700	3,200
Maximum I. H. P.	23,000	23,000	21,000	4,500
Speed (knots)	22	22	22	16.5
	Complete belt.	Complete belt.	Part. belt (200 ft. long)	....
Armour belt	6 in. top. 5 in. bottom. 3½ in. ends.	6 in. 5 in. 3½ in.	4 in. 4 in. ...	None. None. None.

ARMOURED CRUISERS—*Continued.*

	California. Nebraska. West Virginia (sheathed.)	Maryland. Colorado. South Dakota.	St. Louis. Milwaukee. Charleston.	Denver. Des Moines. Tacoma. Chattanooga. Galveston. Cleveland (sheathed).
Battery protection	5 in.	5 in.	4 in.	....
Armament	4 8 in. B.L.R. 14 6 in. B.L.R. 40 small guns.	4 8 in. B.L.R. 14 6 in. B.L.R. 40 small guns.	14 6 in. .... 40 small guns.	10 5 in. .... 14 small guns.
Torpedo tubes	2	2	0	0
Engines	Two sets. $38\frac{1}{2}\times63\frac{1}{2}\times74$, 74 48 in.	Two sets. $38\frac{1}{2}\times63\frac{1}{2}\times74$, 74 48 in.	.... 48 in.	Two sets. $18\times29\times35\frac{1}{2}$, $35\frac{1}{2}$ 54 in.
Revolutions	120	120	125	....
Boilers	Babcock & Wilcox.	Babcock & Wilcox.	Babcock & Wilcox.	6 water-tube.
Heating surface (sq. ft.)	68,000	68,000	58,800	12,600
Grate surface (sq. ft.)	1,590	1,590	1,440	314
Working pressure (lbs. sq. in.)	250	250	250	250
Normal coal (tons)	900	900	650	467
Total bunker capacity (tons)	2,000	2,000	1,500	700

BATTLESHIPS.

	Iowa.	Kentucky. Kearsarge.	Alabama. Illinois. Wisconsin.	Maine. Missouri. Ohio.	New Jersey. Georgia. Pennsylvania.	Virginia. Rhode Island.	Arkansas. Nevada. Florida. Wyoming.
Average contract cost (exclusive of armour).	$3,010,000	$2,250,000	$2,639,300	$2,889,600	$3,640,000	$3,405,000	$860,000
Date of authorisation..	1892	1895	1896	1898	1899	1900	1898
Class................	Sea-going B.	Sea-going B.	Sea-going B.	Sea-going B.	Sea-going B.	Sea-going B.	Coast Def. Monitors.
Length L. W. L.........	360′ 0″	368′ 0″	368′ 0″	388′ 0″	435′ 0″	435′ 0″	252′ 0″
Breadth (extreme).....	72′ 2½″	72′ 2½″	72′ 2½″	72′ 2½″	76′ 10″	76′ 2½″	50′ 0″
Freeboard amidships...	15′ 0″	11′ 0″	19′ 10″	20′ 3½″	18′ 3″	18′ 3″	2′ 6¾″
Mean draught..........	24′ 0″	23′ 6″	23′ 6″	23′ 6″	24′ 0″	24′ 0″	12′ 6″
Displacement..........	11,340	11,540	*a*11,565	*a*12,400	*a*15.320	*a*14.948	*a*3,235
Maximum I. H. P......	12,105	12,180	*a*10.000	*a*16,000	*a*19,000	*a*19,000	*a*2,400
Speed.................	17.103	16.85	*a*16.00	*a*18	*a*19	*a*19	*a*11.5
Armour: Midship thickness	W. L. Belt 14″	16½″ top, 9½″ bot.	16½″ top, 9½″ bot.	11″ top, 7½″ bot.	11″ top, 8″ bot.	11″ top, 8″ bot.	11″
Armour: 13″ or 12″ guns	Turrets 15″	17″	14″	12″	11″	11″	10″
Armour: 8″ "	Turrets 8″	—	—	—	6½″	6½″	—
Armour: 13″ or 12″ "	Barb'ts 15″	15″	15″	12″	10″	10″	11″
Armament...........	4 12″ B. L. R. 8 8″ B. L. R. 6 4″ R. F. 30 Small.	4 13″ B. L. R. 4 8″ B. L. R. 14 5″ R. F. 34 Small	4 13″ B. L. R. 14 6″ B. L. R. — 28 Small	4 12″ B. L. R. 16 6″ R. F.... — 24 Small	4 12″ B. L. R. 8 8″ B. L. R. 12 6″ R. F. 42 Small	4 12″ B. L. R. 8 8″ B. L. R. 12 6″ R. F. 42 Small	2 12″ B. L. R. 4 4″ R. F. — 10 Small

BATTLESHIPS—*Continued.*

	Iowa.	Kentucky. Kearsarge.	Alabama. Illinois. Wisconsin.	Maine. Missouri. Ohio.	New Jersey. Georgia. Pennsylvania.	Virginia. Rhode Island.	Arkansas. Nevada. Florida. Wyoming.
Torpedo tubes..........	Four	Four	Four	Two	Two	Two	—
Engines..............	Two sets. 39×55×85 48″	Two sets 33½×51×78 48″	Two sets 33½×51×78 48″	Two sets 38½×59×92 42″	Two sets 35×57×66 48″	Two sets 35×57×66 48″	Two sets 17×26¼×40 24″
Revolutions............	110	114	120	126	120	120	200
Boilers..............	Cylindrical....	Cylindrical......	Cylindrical......	Water-tube	B. & W.	B. & W.	Water-tube
Heating surface (sq. ft.)	24,082	22,104	21,205	58,104	55,000	55,000	8,800
Grate surface (sq. ft.)...	756	685	640	1,353	1,280	1,280	200
Working pressure......	160	180	180	250	250	250	250
Normal coal cap. (tons).	625	410	800	1,000	900	900	200
Total bunker cap. (tons)	1,795	1,591	1,355	2,000	1,900	1,900	400

(a) Estimated.

Professor Biles called attention to the fact that cofferdams filled with obturating material which is expected to expand when in contact with water are fitted very generally at the sides of the ships. This material is the pith of the corn stock and has been experimented upon very fully by the Navy Department with the result that they prepare their designs with the intention of adopting it generally. It is evident that if the corn stock material swells when in contact with water sufficiently to fill up holes made by shot it will have an important effect upon the margin of stability and probably of buoyancy of the ship in action.

The French government have experimented similarly with cocoa nut fibre.

The gist of all these contrivances is that there is a struggle between the gunners and the ships—a struggle which threatens the ship with fatal consequences from the admission of water into parts lying near the water-line unless they are protected with armour. The ship-builder seeks to avoid this by filling such spaces with coal, or with other water-excluding material. It is not so much to stop holes that it is wanted, but to occupy beforehand with light material vacant spaces into which water would otherwise flow through wounds in the skin. This question is highly important to the British navy in its protected ships and in the ships with short armoured citadels. Yet the British Admiralty are never heard of as experimenting in this direction or as availing themselves of other people's experiments. Both as a matter of buoyancy and stability there is nothing which would so well repay attention in all navies.

The unreadiness of the British sailor to give attention to anything except what is hurtful to the enemy

is well known. He cannot be trusted to adopt or to improvise anything which seems directed towards securing his own safety.

In the manufacture of armour the United States factories have forced the pace in inventive progress. In the chapter on guns reference is made to the progress of the United States gunmakers.

CHAPTER XVI.

BRITISH NAVAL PANICS DURING THE CENTURY.

It cannot be said that the officers of the Royal Navy are satisfied in the face of their responsibilities. Every now and again they shout in the ear of the public, and demand more ships and more men. Such national arousings are known by the profane name of Naval Panics.

More money is then demanded to increase the numbers of the particular ships of "The Great Squadron of His Majesty's Naval Royal" which no longer aids "The Shipping of England" "in commanding the great and large fields of the ocean," but which displaces it, and assumes all its duties as part of the national defences.

It will be interesting to note some of these periodical arousings while the work of displacing and supplanting has been going on. In 1850 Sir Francis B. Head published a book, *The Defenceless State of Great Britain* (John Murray). In it he quotes from "Admiral Bowles, late one of the Lords of the Admiralty," the following letter:—

"Our present force consists chiefly of these objectional classes I have already so severely condemned, and being consequently, wherever they are found, notoriously inferior to the enemy's ships, in that part of the world, will in all probablity be sought and attacked with all the confidence naturally resulting from

the consciousness of superiority; and even if they escape capture will be reduced to the humiliating necessity of a purely defensive system, until reinforcements arrive, while our merchant ships will fall an easy prey to privateers, etc. The 28-gun frigates and 10-gun brigs must inevitably be overpowered by any vessels of war (nominally of their own class) to which they may be opposed, and with which they cannot honourably decline an engagement; but what will be the feelings of the officers and men, whose blood and honour will have been thus wantonly sacrificed, and of their countrymen at large, when the light of truth breaks in upon the nation? When it is seen that enormous sums have been lavished on injudicious and inadequate preparations, and that after seventy millions expended in putting our navy into what was considered a perfect state of equipment we have to throw aside the greater part of our smaller ships, and again recommence operations; will not the burst of public indignation be loud and tremendous, and will it be admitted as a sufficient vindication to allege that, in many particulars, the British navy was far more inferior at the commencement of former hostilities?"

How familiar we are with similar charges written in later years, and in more polished English.

Sir Francis Head gives also a descriptive sketch of the Capture of London by a French army. He points to the absence from the navy of "Gunner-Seamen" as its main defect, and as the prime cause of the failure of the navy to prevent the imagined landing of the French. He quotes further a strong letter from Admiral Sir Charles Napier, the political Admiral of the day.

Sir Edward Creasy in his "Fifteen Decisive Battles of the World," published in 1851, takes occasion to

compare those who deride the idea of the country being in peril from the sudden attack of a hostile expedition with one of the misleading Syracusan orators in B. C. 413.

At this date (1850) England had 86 sail of the Line and France 45. In 1852 Navy Estimates were revised and increased. They were £5,835,588 in that year. The Russian war, which broke out in 1854, found Great Britain in the possession of a powerful steam fleet including two-deckers and three-deckers, but all built of wood, and all, of course, unarmoured. In 1858 the Navy Estimates were £8,851,371.

In December, 1858, and January, 1859, a committee sat under the Administration of Lord Derby "to consider the very serious increase which had taken place of late years in the Navy Estimates while it represented that the naval force of the country is far inferior to what it ought to be with reference to that of other Powers, and especially France, and that increased efforts and increased expenditure were imperatively called for to place it on a proper footing."

One of the main causes assigned for a prospective further increase was the comparative state of preparation of France in respect of powerful screw steamers. The committee reported that the superiority in line-of-battle ships over France in 1850 represented by 86 British to 45 French had vanished, for France had since that date converted all the sailing ships, that were fit, into steam ships and we were obliged to accept the position that steam ships were the only ships really effective for the purposes of war. This move on the part of France had been followed by England, but she had lost time and her superiority was gone. England had now only 29 steam line-of-battle ships, against 29 of the French. The committee recom-

mended the conversion of 19 sailing ships-of-the-line into steam ships-of-the-line and steam frigates. Sir John Pakington in the Spring of 1859 brought in estimates for carrying out these recommendations.

The committee confined its proposals to wooden ships, unarmoured, but Sir John Pakington very wisely decided to commence at the same time two armoured steam frigates and to build them of iron. In coming to this decision he was greatly influenced by the advice of Mr. John Scott Russell. The great naval tactician of that day was General Sir Howard Douglas who in August, 1858, published a book, entitled *Naval Warfare with Steam.* In this book speaking of an unarmoured wooden line-of-battle ship, the "Renown," he said, "The 'Renown' is our best screw steamer and should be the model of those to be hereafter constructed."

In pursuance of the committee's views, and of naval views generally, wooden ships were built and converted for screw ships of war without armour, and in 1861 there were 67 wooden steam ships of war building and converting for the Royal Navy, and Navy Estimates had gone up to 12½ millions sterling.

These 67 ships include ships which had been built, launched and placed in "Ordinary." Technically and in official returns these ships in "Ordinary" were not "building" because they had been launched. But it was the practice of that time to leave about one-eighth of the total work in building to be completed when the new ship was removed from "Ordinary" to be prepared for sea. (Appendix I.) While she lay in "Ordinary," which might be for many years, list pieces were cut out from her planking to admit air to the frames, and the upper deck was covered with a water-tight wooden canopy. Many of these 67 ships

were never completed for sea, for in 1858-9 the French had again changed their ship-building tactics, a fact not sufficiently appreciated by Lord Derby's Committee of that date. At that very time they had four sea-going iron-plated ships building, and this change marked as untimely all the fleet which the navy estimates of 1859 and the immediately subsequent years provided for, except the two armoured ships which Sir John Pakington had introduced. The construction of an armoured fleet went on slowly, and in 1874 the navy was said to be in a shameful condition. Sir J. Hay said in Parliament that naval officers concerned in the administration of naval affairs ought to have resigned their posts rather than to have countenanced a policy resulting in so much mischief. Sir Edward Reed said the government had practically abandoned the naval position of this country in Europe.

We have thus seen, since the last half century commenced, a panic because the wooden sailing ships of war were of inferior types: another because sailing line-of-battle ships had become useless, since there must be steam-power in them: then steam line-of-battle ships built of wood must be armour-plated to make them of any service. Later still wooden steam line-of-battle ships armour-plated had to disappear because wood was not the proper material of which to build them. Subsequently mercantile marine speeds have largely increased, and the Royal Navy speeds of 11 to 14 knots are no longer accepted as satisfactory. With the higher speeds demanded sail power became inadmissible and must be abandoned.

Still later quick-firing guns and "high explosive shells" demanded armour even more imperatively than the common shell guns had done; thick armour was

discredited, and thin armour, widely spread, became again the mode.

In the meantime the transformation in guns has been laborious, costly, and the cause of serious delays. At the end of 1864, £2,800,000 had been spent as we have seen on breech-loading guns, chiefly for the navy, but the breech mechanism proved to be faulty, and the muzzle loader was re-established in favour in England. In 1875 muzzle-loading guns of as much as 100 tons weight were in course of manufacture by Armstrong. Then muzzle-loading guns were condemned by the navy and complete re-armament with breech-loading guns decided on; and so far as the construction of the ships armed with the heaviest guns would admit of it they also must be transformed to suit the new ordnance.

Running through all this shifting scene, there has been a growing sense of the steady degradation of the personnel of "The Shipping of England," so far as any command of "the great and large fields of the ocean" is concerned. This has quickened the national desire for a Royal Fleet equal in power to any conceivable combination of foreign enemies, and capable of ensuring, so it is said, the efficient blockade of all hostile ports.

Those who like splendid isolation may not perhaps notice how difficult it will be for our commercial rivals to submit to this. They say control of the seas, as guardians of the maritime peace, a control arising out of the mercantile shipping itself would be one thing; control of the seas as a question apart from our commerce; by which the British government may, at its will, shut all the traders of a foreign power out of its own ports, and leave them outside, undefended, is quite another thing. This view of the matter has

been forcibly put by a Dutch naval critic in *The Revolution in Naval Warfare.* (Harrison and Sons, St. Martin's Lane, 1867.) The writer has preferred to remain anonymous. He probably thought his teaching would not be palatable to English readers.

During the last half century there has been a great advance in the dimensions of British ships. The exceptional ship of 1852, the "Leviathan," or "Great Eastern," can no longer be regarded as a monster. The needs of commerce have now brought us up to her great length. The advances made by the marine engineers have enabled commerce to employ such large ships, at high speeds, without extravagant dimensions of engines, or excessive cost of fuel. The Royal Navy has been prompt to adopt economical improvements in machinery; and torpedo-boat practice has given to the Royal Navy greatly increased steam pressures and faster running engines year by year.

Ships of the Royal Navy find themselves faced by speeds in mail steamers, over ocean passages, which they cannot rival, because of their less favourable proportions in length and breadth, and because also of the weight of armament they are obliged to carry. For this reason the mail steamer will be able, as a general rule, to keep out of their reach.

Ships of the Royal Navy are faced also by small vessels of immense speed. Already we have a boat of 100 feet in length running at 34 knots. Such vessels could be carried by fleets, and their presence in actions at sea must be reckoned on. That the presence of torpedo boats in naval engagements at sea will modify what are called naval tactics does not seem to admit of question. So also in attempts to blockade a strong port the possession of such vessels by the blockaded fleet must present a most serious difficulty to the

blockaders. When war with Russia was feared in 1884 the one source of anxiety, which it was impossible to relieve by any measures of precaution, was the security of the large ships which were to operate in the Baltic, where a strong force of torpedo boats was known to exist. Still the dimensions and speeds of fighting ships increase. Naval manœuvres have, by their mimic encounters, quickened the popular imagination in favour of these high speeds notwithstanding that such sizes and speeds demand dangerous concentration of officers and men in single hulls. The idea of naval centres, with numerous fast ships, grouped about heavily-armed and well-protected slower ones, is discredited. (See Report of Committee on Designs, 1871.)

British mercantile shipping is conservative in its methods. The control of the Board of Trade and of the Surveyors of the different Registries does not tend to rapid progress. In the Royal Navy advance is stimulated by military rivalries and by the rewards which fall to successful invention in the arts of war. Merchant ships profit slowly by some portions of this military advance, but on the whole the ship of war becomes more and more specialized among ships. Such specialization in war-shipping injures the countries which have the largest shipping interests, and favours those which have the least.

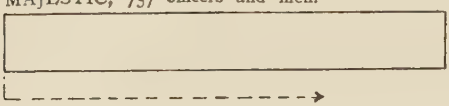
It is the fashion to regard the low British Naval Estimates of the years immediately preceding the Naval Defence Act of 1889 as indicating unwillingness on the part of successive administrations to do justice to the navy.

So far as the policy extending over these years can be gauged it may be said that there was a manifest desire to avoid mere coast-defence ships, and to make

Relative lengths, displacements, or weights, numbers of officers and men in the crews and speeds of first-class ships and of torpedo vessels.

The lengths of the arrows show the number of lengths of the ship or the portions of her length passed over in ten seconds.

MAJESTIC, 757 officers and men.



GOLIATH, 700 officers and men.

ALBATROSS (Destroyer) 60 officers and men.

TURBINIA, 20 officers and men.

all armoured shipping available on the high seas so that as the ships become obsolete they may form coast and harbour defences. Armoured ships of large size were not built, but powerful guns and thick armour were put into ships of moderate size. Protecting decks over machinery and magazines were introduced into all classes of ships. Ships having no side armour were limited in size so that no crews in such ships should exceed 300 men. A minimum speed of 13 knots was fixed for cruisers, and place was found for a large number of vessels of smaller size than the cruisers, for training and for consular service. They were kept of small dimensions and cost so as to multiply the number of independent commands for young officers, and to increase their training power. They were all fully rigged, and were much under sail since their best steam speed did not much exceed their best sailing speed. They had iron or steel frames and copper bottoms. All the existing highly trained officers on the active list of the navy have benefited by the large number of independent commands which these vessels gave. It may be safely said that no foreign vessel of their tonnage could have surpassed these small British ships in fighting efficiency. But foreign vessels were longer, had less sail, were faster steamers, and so, going out of naval favour, these vessels have gradually given place to larger ships worked wholly under steam.

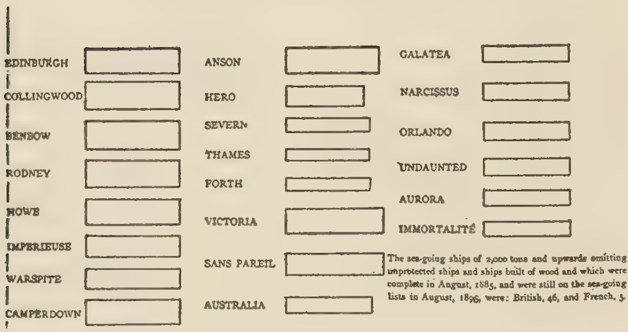
A list of such vessels of less than 2,000 tons displacement between 1872 and 1873, is as follows:—

	Name.	Tons.	I. H. P.	Complement.
Wood Frames.	"Encounter"	1970	2130	220
Wood Frames.	"Modeste"	1970	2180	220
Wood Frames.	"Amethyst"	1970	2140	220
Wood Frames.	"Sapphire"	1970	2360	220
Wood Frames.	"Diamond"	1970	2140	220
	"Satellite"	1420	1110	150
	"Hyacinth"	1420	1190	150
	"Heroine"	1420	1130	150
	"Caroline"	1420	950	150
	"Rapid"	1420	950	125
	"Royalist"	1420	950	125
	"Gannet"	1130	1110	140
	"Wild Swan"	1130	800	140
	"Penguin"	1130	720	140
	"Osprey"	1130	1060	140
	"Cormorant"	1130	950	140
	"Dragon"	1130	1010	140
	"Pegasus"	1130	970	140
	"Miranda"	1130	1020	140
	"Kingfisher"	1130	1090	140
	"Matine"	1130	1120	140
	"Espiégle"	1130	1140	140
	"Doterel"	1130	1120	140
	"Phœnix"	1130	1120	140
	"Fantôme"	940	970	125
	"Albatross"	940	840	125
	"Egeria"	940	1010	125
	"Flying Fish"	940	840	125
	"Sappho"	940	840	125
	"Daring"	940	840	125
	"Wanderer"	925	750	100
	"Dolphin"	925	750	100
	"Rambler"	835	690	100
	"Ranger"	835	760	100
	"Algerine"	835	810	100
	"Flamingo"	780	750	100
	"Griffon"	780	790	100
	"Condor"	750	770	100
	"Falcon"	700	720	100
	"Swift"	756	1010	75
	"Linnet"	756	1050	75
	"Arab"	720	660	100
	"Lily"	720	830	100
	"Frolic"	610	900	77

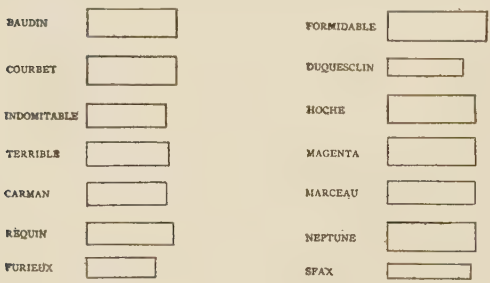
Name.	Tons.	I. H. P.	Complement.
"Kestrel"	610	830	77
"Ready"	610	890	77
"Rifleman"	610	710	77
"Albacore"	560	660	60
"Mistletoe"	560	600	60
"Watchful"	560	600	60
"Cygnet"	455	530	60
"Express"	455	440	60
"Contest"	455	510	60
"Sheldrake"	455	370	60
"Mallard"	455	400	59
"Moorhen"	455	390	59
"Foxhound"	455	470	59
"Forward"	455	450	59
"Firm"	455	480	59
"Firebrand"	455	460	59
"Firefly"	455	470	59
"Redwing"	461	440	59
"Grappler"	465	480	59
"Wrangler"	465	480	59
"Wasp"	465	470	59
"Espoir"	465	470	59
"Banterer"	465	360	59
"Cockchafer"	465	470	59
"Bullfrog"	465	420	59
"Starling"	465	360	60
"Stork"	465	350	60
"Raven"	465	380	60
"Ariel"	438	540	59
"Zephyr"	438	530	59
"Goshawk"	430	480	59
"Swinger"	430	520	59

Another feature of the time we are considering—the seventies and early eighties—was that fast Atlantic and other liners were extensively modified by their owners to make them more secure against foundering from a single underwater blow. This gave them, at the same time, a higher military value, although it still was not much, against armed ships of similar construction.

British armoured and protected ships, building and in various stages of completion, but all incomplete, in August, 1885.



French armoured and protected ships, building, and in various stages of completion, but all incomplete, in August, 1885.



While these aims were pursued the large fighting ships, of 2,000 tons displacement and upwards held in comparison with those of other Powers the position shown in *The Naval Review* of 1886 by the author (E. Marlborough & Co., Old Bailey.)

The large table given in that review showed the ships which were built of wood, and those which were unprotected, and it was clear that French naval policy had not been continuous or sound. Some of the ships were powerful and it could not be said that any were otherwise than well designed, but armoured ships built of wood, and iron ships unprotected, would certainly require to be withdrawn from service in a few years. This was perfectly well known to the French engineers and, in the tables referred to, the efforts they were making in 1885 to get protected ships, and especially armoured ships are shown.

A diagram was prepared for the Greenock Philosophical Society in 1899 and is reproduced here shewing in small rectangular blocks proportionate in length and bulk to the length and displacement, respectively, of the ships all the ships of sea-going types which were complete for sea in several European navies in May, 1898. Ships of less than 2,000 tons displacement have been omitted as being too small to be shewn and ships built of wood and unprotected ships, as being obsolete.

The blocks represent, in length, the relative lengths of the ships, and in area their relative displacements. The spaces between the blocks are proportional to the thickness of the armour by which the vital parts of the ships are protected, so that a group of heavily-armoured ships is made to occupy space in proportion to the significance of the armour protection which it carries. The small circles in the British group divide

the designing periods into four of nine years each; viz. 1859-68; 1868-77; 1877-86; and 1886-95. The last section represents the death duties period in finance.

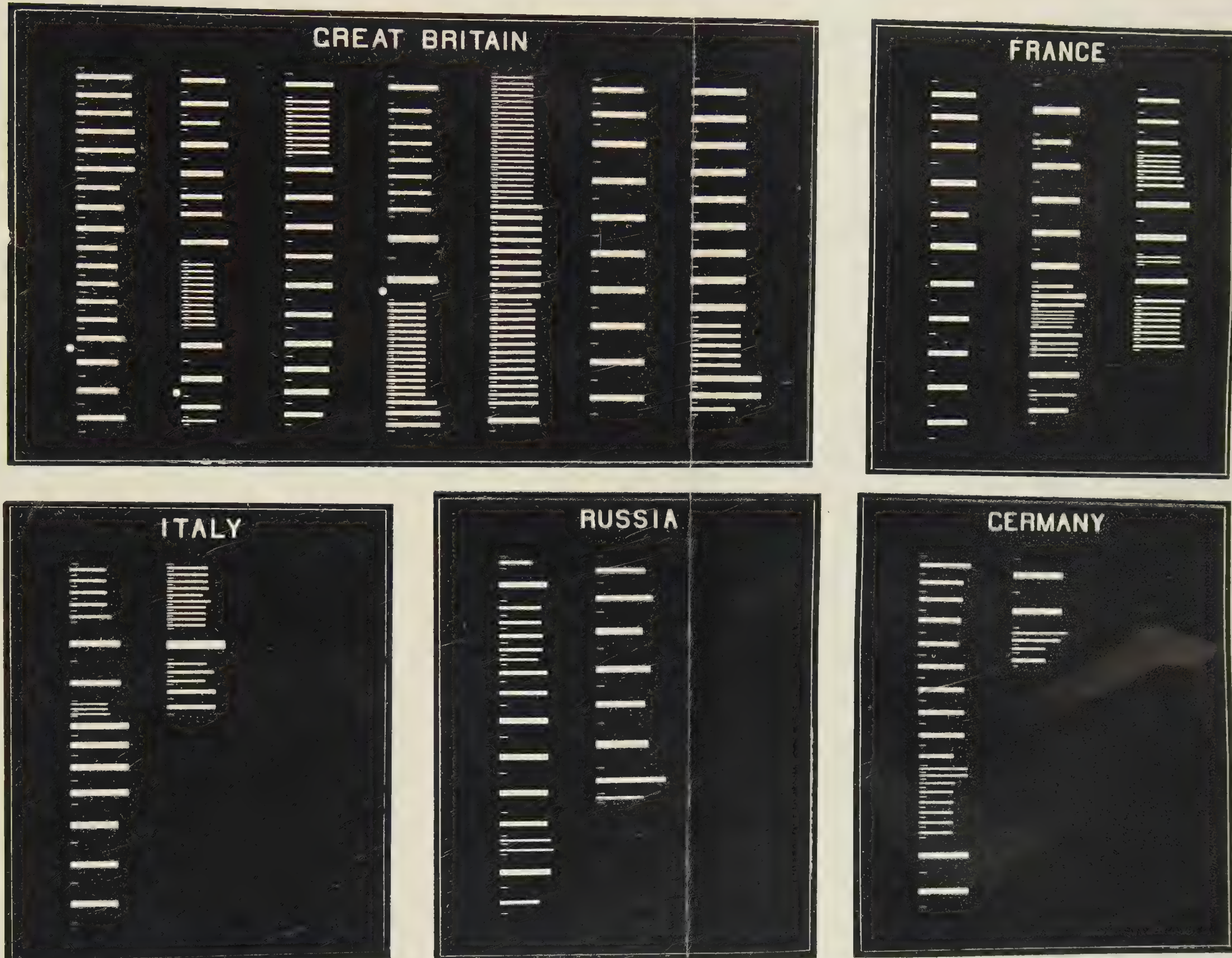
Referring now to the four designing periods in the British list, the ships stand in the following order:—

First period.—"Warrior" (1), "Black Prince" (2), "Achilles" (3), "Minotaur" (4), "Agincourt" (5), "Northumberland" (6), "Bellerophon" (7), "Hercules" (8), "Monarch" (9), "Audacious" (10), "Iron Duke" (11), "Invincible" (12), "Swiftsure" (13), "Triumph" (14), "Sultan" (15).

Second period.—"Devastation" (16), "Thunderer" (17), "Superb" (18), "Neptune" (19), "Alexandra" (20), "Shannon" (21), "Dreadnought" (22), "Temeraire" (23), "Nelson" (24), "Northampton" (25), "Inflexible" (26), "Cleopatra" (27), "Comus" (28), "Curaçoa" (29), "Champion" (30), "Conquest" (31), "Carysfort" (32), "Constance" (33), "Cordelia" (34), "Calypso" (35), "Calliope" (36), "Ajax" (37), "Agamemnon" (38).

Third period.—"Conqueror" (39), "Polyphemus" (40), "Colossus" (41), "Leander" (42), "Arethusa" (43), "Amphion" (44), "Phæton" (45), "Mersey" (46), "Severn" (47), "Thames" (48), "Forth" (49), "Edinburgh" (50), "Collingwood" (51), "Rodney" (52), "Howe" (53), "Benbow" (54), "Camperdown" (55), "Anson" (56), "Imperieuse" (57), "Warspite" (58), "Hero" (59), "Sans Pareil" (60), "Australia" (61), "Galatea" (62), "Orlando" (63), "Undaunted" (64), "Immortalité" (65), "Narcissus" (66), "Aurora" (67), "Nile" (68), "Trafalgar" (69).

The corresponding ships on the French list at the end of the third period are:—"Friedland" (1), "Redoutable" (2), "Devastation" (3), "Duperrè" (4),



Ships of Over 2,000 Tons Displacement in the Navies of Europe in May, 1898.

"Vauban" (5), "Baudin" (6), "Courbet" (7), "Indomptable" (8), "Terrible" (9), "Caiman" (10), "Requin" (11), "Formidable" (12), "Duguesclin" (13), "Hoche" (14), "Magenta" (15), "Marceau" (16), "Neptune" (17), "Sfax" (18).

During the next nine years of the thirty-six, the French added to their list thirty-six ships, and the British eighty-eight ships.

The names are:—(French) "Tage" (19), "Cecile" (20), "Troude" (21), "Coëtlogon" (22), "Cosmão" (23), "Surcouf" (24), "Davout" (25), "Dupuy de Lôme" (26), "Alger" (27), "Jean Bart" (28), "Isly" (29), "Brennus" (30), "Latouche-Treville" (31), "Jemmapes" (32), "Valmy" (33), "Bouvines" (34), "Trehouart" (35), "Suchet" (36), "Friant" (37), "Chasseloup-Laubat" (38), "Bugeaud" (39), "Charny" (40), "Chanzy" (41), "Charles Martel" (42), "Jaureguiberry" (43), "Linois" (44), "Bruix" (45), "Carnot" (46), "Foudre" (47), "Galilée" (48), "Cassard" (49), "D'Assas" (50), "Du Chayla" (51), "Pascal" (52), "Descartes" (53), and "Pothuau" (54).

The British ships of the fourth period are placed in the order in which I give the names, as follows:—"Melpomene" (70), "Marathon" (71), "Medea" (72), "Medusa" (73), "Magicienne" (74), "Ringarooma" (75), "Mildura" (76), "Katoomba" (77), "Tauranga" (78), "Philomel" (79), "Pearl" (80), "Phœbe" (81), "Pallas" (82), "Wallaroo" (83), "Vulcan" (84), "Blake" (85), "Blenheim" (86), "Sybille" (87), "Pique" (88), "Thetis" (89), "Naiad" (90), "Terpsichore" (91), "Sirius" (92), "Andromache" (93), "Melampus" (94), "Latona" (95), "Iphigenia" (96), "Æolus" (97), "Scylla" (98), "Retribution" (99), "Brilliant" (100), "Intrepid" (101), "Sappho" (102), "Rainbow" (103), "Indefatigable" (104), "Spartan"

(105), "Tribune" (106), "Apollo" (107), "Edgar" (108), "Endymion" (109), "Royal Arthur" (110), "Hawke" (111), "Theseus" (112), "St. George" (113), "Gibraltar" (114), "Crescent" (115), "Grafton" (116), "Pelorus" (117), "Bonaventure" (118), "Forte" (119), "Flora" (120), "Hermione" (121), "Fox" (122), "Charybdis" (123), "Astræa" (124), "Cambrian" (125), "Eclipse" (126), "Venus" (127), "Minerva" (128), "Talbot" (129), "Centurion" (130), "Barfleur" (131), "Renown" (132), "Royal Sovereign" (133), "Empress of India" (134), "Hood" (135), "Repulse" (136), "Ramillies" (137), "Resolute" (138), "Revenge" (139), "Royal Oak" (140), "Magnificent" (141), "Majestic" (142), "Illustrious" (143), "Cæsar" (144), "Hannibal" (145), "Mars" (146), "Jupiter" (147), "Victorious" (148), "Prince George" (149), "Isis" (150), "Dido" (151), "Doris" (152), "Diana" (153), "Juno" (154), "Powerful" (155), "Terrible" (156), and "Arrogant" (157).

The displacement or bulk of each of these ships is represented fairly to the eye; so also is the significance of the armour protection.

There are points of great importance as to whether there is armour on the sides, and, if so, how high it rises and how far it extends along the sides of the ship. These I have been unable to show on the diagrams.

One thing which I desire to bring out is the indicated horse-power with which these ships are driven. It works out as follows:—

	I. H. P.
Germany	167,800
Russia	217,400
Italy	286,300
France	482,800
Great Britain	1,362 300

There are over 2½ millions of horse-power in steam machinery in these sections of five great navies.

The four foreign powers taken together have 85 per cent of the steam power of the ships on the British list. The mean power per ship is:—

German	6,415
British and Italian	8,677
Russian	8,690
French	8,940

LIST OF RUSSIAN SHIPS ON DIAGRAM.

"Kniaz Pojarsky" (1), "Peter the Great" (2), "General Admiral" (3), "Duke of Edinburgh" (4), "Vladimir Monomach" (5), "Dimitri Donskoi" (6), "Rynda" (7), "Alexander II." (8), "Nicolas I." (9), "Ekaterina II. (10), "Tchesma" (11), "Sinope" (12), "Admiral Nakhimov" (13), "Admiral Kornilov" (14), "Pamyat Azova" (15), "XII Apostles" (16), "Gangut" (17), "Navarin" (18), "Rurik" (19), "George the Victorious" (20), "Petropaulovsk" (21), "Sisoi Veliki" (22), "Three Saints" (23), "Rossiya" (24), "Svetlana" (25).

LIST OF GERMAN SHIPS.

"König Wilhelm" (1), "Preussen" (2), "Friedrich der Grosse" (3), "Kaiser" (4), "Deutschland" (5), "Sachsen" (6), "Baiern" (7), "Wurttemberg" (8), "Baden" (9), "Oldenburg" (10), "Irene" (11), "Prinzess Wilhelm" (12), "Beowulf" (13), "Siegfried" (14), "Frithjof" (15), "Heimdall" (16), "Hildebrand" (17), "Hagen" (18), "Weissenburg" (19), "Kurfürst Friedrich Wilhelm" (20), "Brandenburg" (21), "Wörth" (22), "Kaiserin Augusta" (23), "Gefion" (24), "Odin" (25), "Ægir" (26).

LIST OF ITALIAN SHIPS

"Maria Pia" (1), "San Martino" (2), "Ancona" (3), "Castelfidardo" (4), "Affondatore" (5), "Duilio" (6), "Dandolo" (7), "Flavio Gioja" (8), "Vespucci" (9), "Giovanni Bausan" (10), "Italia" (11), "Lepanto" (12), "Re Umberto" (13), "Sicilia" (14), "Lauria" (15), "Morosini" (16), "Doria" (17), "Stromboli" (18), "Vesuvio" (19), "Etna" (20), "Fieramosca" (21), "Dogali" (22), "Piemonte" (23), "Liguria" (24), "Etruria" (25), "Lombardia" (26), "Umbria" (27), "Sardegna" (28), "Elba" (29), "Marco Polo" (30), "Calabria" (31), "Carlo Alberto" (32), "Vettor Pisani" (33).

The French navy was at the beginning of the period of expansion quite inadequately represented by large fighting ships. There was uncertainty as to approaching developments in guns, in armour, and in machinery. The French Naval Commission of 1886 demanded that no expense for a new armour-clad should be incurred before the express sanction of the Chamber of Deputies had been obtained. England

was informed on Admiralty authority that the two ships laid down in August, 1885, (the last two in the third period), would probably be the last large ironclads built. At that date (August, 1885), the French navy consisted almost entirely of wooden ships and unprotected ships. The French ships of that date which were completed for sea, which were of seagoing, non-obsolete types, and which were of at least 2,000 tons displacement, numbered only eleven; viz. "Heroine," "Friedland," "Redoutable," "Devastation," "Duperré," "Vauban," "Tonnerre," "Fulminant," "Tempête," "Vengeur," and "Tonnant." Since that date the five last named have been degraded by removal from the sea-going lists, and the first has disappeared from the lists altogether.

The wooden and unprotected ships in the French list of August, 1885, were 49 in number. Of the same class of obsolete ships there were at the same date in the British list only 19. As against the eleven non-obsolete French ships there were 56 in the British list.

The lists of *such obsolete ships of 1885*, either built of wood or unprotected, are as follows:—

British ships:—"Lord Warden," "Repulse," "Inconstant," "Shah," "Volage," "Active," "Rover," "Boadicea," "Bacchante," "Euryalus," "Iris," "Mercury," "Raleigh," "Opal," "Tourmaline," "Turquoise," "Ruby," "Emerald," "Garnet." *In May, 1898, twelve of these had disappeared.* The seven still remaining are not shown on the diagrams.

French ships of *obsolete type corresponding* with the above were as follows:—"Provence," "Valeureuse," "Surveillante," "Richelieu," "Savoie," "Flandre," "Revanche," "Belliqueuse," "Alma," "Duquesne," "Tourville," "Thetis," "Taureau," "Ata-

lante," "Montcalm," "Reine Blanche," "Cerbère," "Belier," "Bouledogue," "Tigre," "Ocean," "Marengo," "Infernet," "Sané," "Suffren," "La Galissonière," "Champlain," "Turenne," "Iphigénie," "Naiade," "Arethuse," "Colbert," "Trident," "Victorieuse," "Triomphante," "La Perouse," "D' Estaing," "Nielly," "Duguay-Trouin," "La Clocheterie," "Dupetit-Thouars," "Fabert," "Seignelay," "Villars," "Forfait," '"Magon," "Roland," "Primauguet," and "Bayard."

In *May, 1898, thirty-one of these ships had disappeared* from the lists. The eighteen still remaining are not shown on the diagrams.

I have referred particularly to these facts because they are contrary to much cherished British opinion. But the facts were so well known to French naval constructors and naval officers that when comparisons were made in England highly favourable to France they used to say sadly that they only wished the writers could be made to prove their confident statements. We are in danger of overlooking most important distinctions if we include wooden ships and unprotected ships in reckoning the power of fleets of fighting ships. I have omitted them from all the diagrams. Otherwise the diagrams represent the facts presented to Parliament by the Admiralty on the 17th May, 1898.

It was in 1885-86 and immediately before and after it that the country was charged with having allowed the navy to fall below that of France. What truth there was in the charge may be seen by these facts.*

*Mr. H. W. Wilson a well-known writer of repute on naval questions, writing in Sept. 1899 on the Naval Administration of the Century, speaks of the "panic and wasteful expenditure involved in the alarm of 1885." The author is

The French naval authorities were straining every nerve to satisfy their own reasonable needs, and to make this a plea for an immense increase in the British navy, was hardly fair. It does not follow that the increase was not wise and right. No one who thinks about our naval requirements, with our helpless mercantile marine, can ever think we have too many ships or too many men. The country demanded the increase; the money was found for it, the materials, the guns, good types of engines and boilers, the dockyards, and the designers were ready, and the work has been done rapidly and well. But those men who belittled the British navy, in 1885, as compared with that of France were either ill-informed or not very scrupulous.

The question now is what will be done with this fleet. Do not let it be supposed that it will remain proof against the weapons of naval war for many years. Its triumph will no doubt be brief; and men will be saying, not many years hence, how unwise it is to expect anything approaching finality in such matters.

The possession of such a fleet affords an opportunity to British statesmen which may never occur again in their time. Conscious of its strength the nation might try once more and perhaps is now trying the value of a policy it has sometimes, but very rarely favoured. It might try to remove causes of offence between us and our neighbours. It might even go

in a position to judge with knowledge and fairness in this matter and he says confidently that in the face of probable war in 1885 with Russia there was no sign whatever of panic in the British Naval Administration or of wasteful expenditure. The question of alleged wasteful expenditure is dealt with in the Chapter on the Utilization of the Mercantile Marine.

so far as to test the truth of a principle on which much of the strength and joy of private life depends. It might try whether it is not true for nations, as well as for individuals, that it is more blessed to give than to receive. So far as this is being done the writer, for one, is thankful.

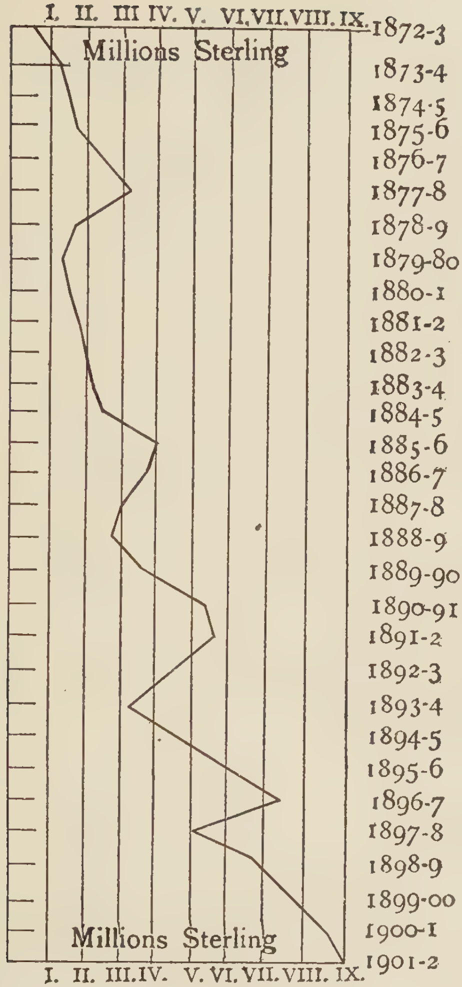
By the kind permission of Lord Brassey a diagram prepared by him shewing the actual expenditure on new ships of war for the British Navy, 1872-1902, is given here.

As we study it we ask ourselves whether it is not time that some reasonable settlement should be made as to shipbuilding expenditure for a war navy.

We may not get for many years yet, either the international protection of private property at sea or the gradual incorporation of warlike features in fast merchant shipping. Either of these measures would at once reduce the demand for special armed ships. But apart from success on these lines there are considerations which go in the direction of some necessary limit to this expenditure. As matters now stand as soon as the sailor marks some new power of offence or defence making its appearance in a ship of war he wishes to see this new power in immediate operation throughout the British navy. He is not content with the introduction of these new features into British ships at such a rate as will keep abreast of three other navies combined. He desires that all ships shall be condemned in his own navy which do not possess these superior qualities. So a great reconstruction is demanded every few years and a wholesale withdrawal of ships from the effective Navy List.

This demand of the fighting man for the most perfect weapon throughout his entire armoury, however

Actual Expenditure upon the Construction of New Ships.



From Brassey's Naval Annual

often the change may be necessary, has a curious effect upon the good Admiralty and War Office Official. He does not hesitate to take up an attitude of hostility to all innovation and to do his best to suppress it. Sad experience as to what advancing tides will do is perhaps working changes in the official mind, but the author well remembers the authority and seriousness with which the doctrine was held fifty years ago.

The party in the British Parliament and Press which forces the pace of reconstruction to-day has no such justification as they had who drove out the sailing ship and the wooden ship. This modern party treats the muzzle-loading gun armament as being vital in the sense that the use of steam was. There are sailors in high commands to-day who appear to take this view as to the total disqualification imposed by the absence of breech-loading ordnance in a ship. These same men, when they were younger, spoke as strongly as to the disqualification imposed by the presence of breech-loading ordnance in a ship. Nothing, in those days of their ardent youth, would satisfy them but the entire rearming of the fleet with what they called the well-known and trusted muzzle-loader. The breech-loading guns might have been retained for all they were worth and in course of time men would have become familiarised with them. Defects and weaknesses would have been soberly valued and gradually removed. This would not do. Every ship must be as perfect as it was possible to make it. Moreover the requirements of drill and of uniformity of stores was imperative, and the inferior breech-loading gun must go. We had to pay heavily for that and we are called upon now to reverse the process and get rid of all ships having a muzzle-loading armament. These reconstructions take the same course in the matter

of speed. A certain number of ships fell below a standard of speed which they have in their minds, but which none of them can justify by any sound reasonings or coherent imaginings. Such ships, they say, must be regarded as obsolete and should not be reckoned at all in estimating the relative strength of navies. This limit of speed is not a matter of agreement among these critics. They agree only in this that the limit rises as each new and faster ship is produced. The well-trained government official will not produce a faster ship if he can help it, or at least the improvement shall be very small, but the designer for some small foreign power comes with the best that can be done in speed, and the official ships drop hopelessly astern. If a large ship of war of 20 knots sea-going speed were produced somewhere to-morrow we should find that the line between useful and useless ships would shift its place immediately in critical notices of the navy. Ships which were reckoned last month as effective would be struck out. If the new ship had more than 20 knots England would be regarded as lost if she pinned her faith any longer on the existing navy.

But this is eminently unreasonable. Every well-built and well-protected ship of war has, and always continues to have a fighting value in proportion to its displacement or total weight. Experience shows that the progress of invention lessens this fighting value by something like 2½ per cent every year after the completion of the ship until, at the end of twenty years, the ship although kept in a perfect state of repair has lost 50 per cent of the value originally due to its displacement, as a seagoing ship.

It is probable that no well-built steel ship, carefully maintained as a structure, ever loses more than half

its first value as part of a great navy. This would not be true of ships in which speed is the ruling factor. They become obsolete sooner and more seriously.

It is a question whether at each recommission, in time of peace, the number of officers and men should not be reduced in favour of newer ships in the proportion that the efficiency of the ship has been reduced by lapse of time.

It may be well to add here the last British cry of alarm as to the navy. It is a letter entitled *A National Danger* published in the London *Times* in large type on 1st July, 1901.

"The Crimean War may fairly be said to have injured the cause of national defence by obscuring its vital requirements. The defects of our military system were so palpable and the unnecessary suffering and humiliation which they directly entailed were so keenly felt that public attention was absorbed by the crying needs of the army. It was thus forgotten that the campaign had been rendered possible only by the command of the sea, that disaster was averted only by the naval supremacy which enabled our perishing forces to be recruited and re-equipped, and that if naval inferiority ever befell us the Empire would be indefensible. Oblivion of the greatest lesson of the war sufficed to warp our policy and to induce neglect of the Fleet. It followed that for years, our position was one of peril, none the less real because at the time unrecognized. So completely was the teaching of centuries of history ignored and so absolutely were the national needs misunderstood that when, in 1859, widespread uneasiness as to the designs of France prevailed, safety was sought in volunteers and in fortifications, while our naval strength was allowed to decay.

"After a long period of grave national danger the rehabilitation of the Fleet was at length undertaken in response to an appeal to history and to reason; but the waste to which the mis-reading of the lessons of the Crimean War directly led defies calculation.

"Precisely the same baneful result appears likely to follow the war in South Africa. Again serious defects in our military forces—defects many of which cannot be ascribed to inadequate military Budgets—have been manifested. Again the vitally important duties discharged by the navy on the seas are imperfectly realized. And again there is a strong tendency in the direction of greatly increased army expenditure without any regard for the higher policy of defence.

"If the fleet is inadequate, ill-formed, or unprepared for war, no increase to our military forces can bring any accession of strength to the Empire. If the navy is in want of funds, we have no right to divert a shilling to the service of the army.

"Unfortunately, the situation is now far more serious than in the years which followed the Crimean War. Our neglect of the navy encouraged French competition and left us with heavy arrears to make good. Two European navies, those of Russia and Germany, have attained dimensions never anticipated and are rapidly increasing. The splendid isolation on which we seem to pride ourselves was never so marked as now. Nor at any previous time have we been regarded with such general dislike and suspicion as now visibly prevail. Never before in our long history was naval strength so absolutely essential to our national security.

"Nevertheless, we choose a time when our naval deficiences are manifold to add about 35 per cent to

our military expenditure. Stokers being sorely needed for our ships of war, we more than triple the yeomanry, which is to be trained annually for 13 days at great cost. The Mediterranean Fleet stands in the forefront of the naval position. If it were defeated, or even prevented from taking the offensive, the results would be disastrous. It is madness to trust anything to chance in the Mediterranean or to believe that, when war breaks out, deficiencies can be supplied. Time will certainly not be there accorded to us, as has happily been the case in South Africa. Yet, when the Mediterranean Fleet has pressing needs, it is actually proposed to spend £1,700,000 annually upon additions to the Auxiliary forces. The fiddling of Nero when Rome was burning can be far more easily justified than this amazing performance. It is necessary that the reserves of munitions of war, which have never been adequately maintained, should be brought up to a reasonable standard. The ill-judged parcimony of successive governments must now be atoned for by a heavy outlay. Such necessary expenditure cannot be grudged; but much of the large increment claimed by the War Office does not fall into this category. To squander money upon Auxiliary forces at a time when the fleet is in want of men and of ships implies national insanity. Is it too late to make a transfer from Army to Navy Votes, or must we contemplate a fresh development of the dangerous impolicy which followed the Crimean War."

CHAPTER XVII.

THE INFLUENCE OF THE SUEZ CANAL UPON BRITISH NAVAL DEVELOPMENT.

The opening of the Canal gave an opportunity to British shipowners to open new lines for sea-carriage to India, Australia, New Zealand, China and Japan, and the opportunity was not lost. British ship-builders benefited very greatly by the opening of the new route because new types of ships were needed.

The daring enterprise of M. de Lesseps and the enthusiastic financial support given to him by the French people thus had as a first consequence an immense advance in British trade and manufactures. But while it did this it struck a heavy blow at the naval might of Great Britain by the change it brought about in the character of the shipping on the great trade routes. The route by the Cape of Good Hope gave a chance to sailing ships in their competition with steam ships, and the East India Ships were fine training fields for seamen. Gradually the East-India-Men and the China clippers found themselves cut out by steam carriers through the canal and a glance at the diagrams and tables given in this book will show how the sailing ship is being forced out of the British carrying trade. Not only do sailing ships cease to train seamen: matters are worse than is told in that statement, for the steamship becomes gradually less and less fitted to give equivalent training.

The Royal Navy has suffered by this change of route to India in the suppression of troop transport by the Cape.

It was decided that since it would be cheaper to send troops in large steamers by the canal to India such steamers should be built. They were mere floating hotels with an army of servants and a handful of sailors and they had no training power for seamen.

Great Britain suffered also most seriously in another way by this change. The Indian troop service brought the Cape Colony into touch with home, and money was spent there which encouraged trade in the Colony. When the change was made Egypt and Red Sea ports gained at the expense of the Cape and it is very probable that had the British government foreseen what was to happen in South Africa they would have decided to keep up the home tie and maintain the sea training of the men. They would have built troop-cruisers for India, working always round the Cape. It may be that the mean saving on troop service has had much to do with colonial alienation in South Africa. One thing is evident. The change of route has made Egypt so important to England that France has seen the growth of British interest there with vexation and heart-burning. M. de Lesseps has been the means of bringing England and France to the verge of war over Egyptian troubles and has created a perpetual cause of misunderstanding there. All the events in Egypt from the bombardment of Alexandria to the overthrow of the Dervish power grew out of the creation of the canal.

It is extremely likely that had the old Cape route for Commerce and especially for Indian transport

been maintained there would have been no Boer difficulties with Great Britain.

If the canal between the Atlantic and the Pacific were made, some such transformation would come over American and Canadian shipping. Ships would be built on the eastern seaboard of the North American continent to create trade with the western ports of South America.

Brazil and Argentina open up very slowly and the prospect of the creation of markets in South America from their ports is very gloomy. The Spanish communities on the Pacific side are more enterprising and would offer a good opening for American capital if there were a canal.

The magnificent rivers flowing through thousands of miles on their way from the mountains to the Atlantic announce clearly enough that the future of South America lies mainly in the development of the countries lying east of the mountain ranges, but there is some five thousand miles of Pacific seaboard in South America which would be brought by a canal nearer to New York and Montreal by sea than it is to any part of Europe.

The steam vessels passing through the Suez Canal in 1900 were 3,441 of 9,378,152 net tons; of these 1,935 of 5,605,221 net tons were British. The number of troops carried through the canal in 1900 was 154,249 and the number of civilian passengers was 102,415.

CHAPTER XVIII.

THE UTILISATION OF MERCHANT SHIPS FOR WAR PURPOSES.

The withdrawal of postal steamers from auxiliary armed service had much to do, as has been said elsewhere, with the lapse of the iron steamers in reasonable provision for safety at sea in the event of collision or of rending open the bottom by grounding.

Mr. Ward Hunt caused an enquiry to be made as to what elements could be secured in such ships for armed service and it was found as has also been stated that the bulkhead subdivision was seriously defective throughout the mercantile marine. The principal lines were but little better than the inferior ones.

In 1877, the author, after describing at the Institution of Naval Architects the various defects of the merchant steamer for use in war, said that when Mr. Brassey (now Lord Brassey) first proposed some time before to revert to subsidies for merchant steamers for war purposes he told Mr. Brassey that he had considered it many times, but that these difficulties stood in the way.

The author went on to say that Mr. Ward Hunt had not been disposed to rest at this point. Assuming that such ships would be no match for unarmoured ships properly built for war purposes they would evidently be the equals of ships of their own kind em-

ployed by the enemy, and these would be certain to be numerous and most formidable against sailing ships and slow steam ships. If, said the author, I went no further I should have made out a case for asking the owner of our fast ocean-going ships to look after his bulkheads; to consider how he might protect his machinery and hull about the water-line; and how he might best arm himself. I might fairly ask him to do this in his own interest—because if he remains under the flag he must run the risks of war in his ordinary business. He may of course be chartered or bought by the government, but the most suitable ships will in that case command the first purchase and the best prices.

Reference was then made to the fact that the Admiralty had authorized the formation of a list of ships with the promise of preferential employment. Such ships were to be inspected by Admiralty Officers, their bulkhead arrangements shewn on plans to be recorded at the Admiralty and an undertaking given that the bulkheads would be so arranged and maintained that the ship would continue to float with any single compartment thrown open to the sea.

Hundreds of ships were modified by owners at their own expense to meet these conditions and secure a place on the list.

The author said: I must express my joy—I can use no weaker word—at the ready acceptance by all the great shipowners in the United Kingdom of the Admiralty bulkhead condition. It may take many years to recover lost ground and bring all first-class steam-ships up to the standard, but the acceptance of the standard is now an accomplished fact and I trust we shall never again see in England a first-class steam-

ship designed which would not float in smooth water although only one of its compartments had been brought into full communication with the sea.

But I am disposed to think we may go considerably further than merely providing for self-defence. I believe the ships may be so defended and armed, as to become not only quite capable of defending themselves and of destroying armed ships not regularly built for war, but also most useful auxiliaries in all important naval operations. It is quite certain that they can at a few hours' notice be efficiently defended by a shot-proof screen across the deck before the machinery, and can as a rule, be quickly and inexpensively armed. The extent to which, with suitable protection and armament, they could be employed in naval warfare, may be thought out, if we consider what those operations will be. I think they may be summarised as follows:

NAVAL OPERATIONS IN WARFARE.

Defensive.

1. Self-protection by merchants or travellers on the high seas against rovers, whether men-of-war or armed merchant ships.
2. The patrol of the highways of commerce by vessels in the employment of the government, for the destruction or capture of rovers.
3. Clearing the offing of important harbours, at home and in the colonies, of hostile vessels, including breaking the attempted blockades of ports.
4. Convoying merchant ships.
5. Protecting harbours, naval stations, and coasts, at home and in the colonies, against violation.

Offensive.

1. The capture of trading ships belonging to the enemy, or liable to capture on his account.

2. The infliction of injury upon harbours, naval stations, and coast towns, and landing military forces on the enemy's territory.

3. Disabling or destroying the armed ships of the enemy.

4. Blockading the principal ports of the enemy to prevent the passage of merchandize inwards or outwards, and to lock up his armed ships.

5. Transporting troops, stores and munitions of war, and keeping up communications by despatch vessels.

Of the five classes of work placed under the head of defensive warfare, a fast merchant ship armed could perform two, in independence of the regular ships of war, and could take part in all the rest as auxiliaries to the iron-clads. And a precisely similar statement holds good with regard to the five classes of work placed under the head of offensive warfare. I do not stop to particularise these as a little study of the question will, I believe, ensure acceptance of this view.

There are certain general principles which may be accepted as arising out of the relation between the several types of fighting ship.

1. The iron-clad ship will, as a rule, be slower and have less coal endurance than the first-class unarmoured or lightly-armoured ship. The iron-clad ship will therefore be unable to force the first-class unarmoured or lightly-armoured ship to engage her.

2. In duels between fast unarmoured or lightly-armoured steam-ships, the ship with most guns—sup-

posing them to be equally good and equally well served—will generally be the victor, whatever the relative speeds or turning powers of the ships may be, because such actions will generally be determined at long ranges.

3. Since the merchant ships cannot mount numerous guns, they will, even when armed, find the modern regular ship of war almost always their victor in single combat, and fast unarmoured or lightly-armoured ships will be more effective against armed merchant ships than iron-clads would be.

It follows from this that fast unarmoured or lightly-armoured ships of war must be of great consequence to a navy against which armed merchant ships may be employed by an enemy.

4. The speed with which fast steam-ships can, in any weather, bear down at night upon slower steam-ships and sailing-ships, and the terrible nature of the attack they can make upon such ships with shells, the ram, and the torpedo, will make it impossible to convoy successfully sailing-ships and slow steam-ships, in face of the attack of even unarmoured ships, provided they are fast and efficiently armed.

And if successful navigation of sailing-ships and slow steam-ships under convoy is impossible, still less will it be possible to navigate such ships safely without convoy.

The inferences I would draw from the foregoing considerations are:—

1. That the merchant-ship which was at one time the equal of the ship of war, which continued to hold a high place in naval warfare until far into our century, gradually lost its place for the reasons I have given, and eventually fell into contempt among naval men for war purposes.

2. That the extension, in point of space, of delicate machinery in the ship of war, and the perfection of the explosive missiles with which it may be attacked above and below the water, have together within the last few years been gradually bringing the two kinds of ships again together, except where armour is used.

3. That the appreciation of this fact on the part of the ship-owners should produce gradually a still closer approximation, so far as it can be made consistently with success in commercial pursuits.

4. The appreciation of it on the part of the government might bring about such an arrangement as would secure for the state the services of all suitable vessels in the event of war, and prevent them from passing into the hands of our enemies.

5. The possibility of forming efficient colonial contingents to the Imperial naval forces for colonial defence becomes less remote. Colonial naval reserves may be created and built up within the colonial trading fleets to be supplemented by and worked with heavy iron-clads, furnished by the Imperial Navy, to be stationed at the most important points of the colonial coasts.

I repeat, that with a wider knowledge of the weak points in the fast steam merchant ships, regarded from the point of view of the Royal Navy, the suggestions I have offered may have the effect of bringing about valuable changes, without in any way interfering with the sound commercial qualities of the ships.

We have a magnificent national possession in our mercantile steam fleet. A large portion of it possesses high speed, coal endurance and seaworthiness. It needs to be manned by trained British seamen, and to be at the service of the state.

The chief surveyor of Lloyd's Register said with regard to the water-tight bulkheads arranged for in the Admiralty list that they would be a great source of safety to ships; he said that the Rules of Lloyd's Register formerly required these bulkheads; and the admission of midship bulkheads continued only to the middle deck, which rendered them useless as a defence against foundering was entirely owing to the action of Admiralty officers superintending vessels chartered to carry troops. Shipowners preferred to lose their class at Lloyd's rather than carry up the engine room bulkheads beyond the middle deck as they would therefore sacrifice their chances of employment as troop ships.

Unhappily the same department gave cause of complaint subsequently to shipowners who had altered their ships and found as they alleged, no preference given to their ships over ships which were not on the Admiralty list.

In 1885, in the prospect of war with Russia the Admiralty took action in this matter. For some years previously guns, mountings and ammunition had been provided at distant ports in British possessions suitable for the best ships on the Admiralty list or for any fast well-built steamer.

All suitable ships were at once taken up by telegraph in Australia, China, and on other stations where the ships were and they were armed.

Lord Brassey describing what happened says:—

"In the spring of 1885, in prospect of war, 16 ships of this superior class as to speed on the Admiralty list were taken up in different parts of the world as armed cruisers. They had a total gross tonnage of 78,397, and varied in average ocean speed from 12

to $18\frac{1}{2}$ knots. Ten of these ships had average ocean speeds of 14 knots and upwards, and six had 16 knots and upwards. At the same time 118 transports were engaged. Of these 25 were on the Admiralty list."

In the statement of the First Lord of the Admiralty, presented to Parliament with the navy estimates for 1887-8, reference is made to the utilisation of auxiliary resources as follows:—

"The inquiries, which an Intelligence Department must needs make, brought before the Board in forcible contrast the great disproportion between the volume of floating commerce of the Empire to be protected and the force at present available to protect it, compared with the mercantile and war marine of foreign nations. To bring the British Navy and commerce into the same relative proportion as that which exists elsewhere in Europe is neither needed nor practicable. To carry out a plan which, at the approach of war, would immediately convert our fastest and most powerful merchant vessels into effective war cruisers, and thus turn the assailed into assailants, seemed a natural solution of the difficulty; but there were various obstacles to its realization. The cost of retainers, the difficulty of providing crews and stokers, the delay in the alterations necessary, the contingency that when wanted the vessel might be at the other end of the world—these difficulties in combination deterred previous Boards from making the experiment.

"It occurred to us that the Post Office expenditure might be utilized, and that if we worked in combination, postal contracts could be associated with conditions by which the use of the vessels carrying the mails might under certain contingencies be economically secured to the state. The revision of the North

American contract was a most favourable opportunity for a trial of the idea. The White Star Company, one of the tenderers, had expressed their willingness to build two vessels to be approved by the Admiralty, of a speed and strength superior to any merchant ship afloat, with engines and boilers below water, with fittings for guns built in during construction, and, when manned, with half crews of Naval reserve men.

"In return for their use, the company requested an annual subsidy which would recoup the owners a portion of the larger outlay the exceptional construction of the vessels required.

"The Cunard Company, another of the tenderers, has the fastest English ships afloat. A large portion of the officers and men in the employ of the Cunard Company are Naval reserve men. Their ships are never more than eight days distant from Liverpool, and, therefore, always obtainable at short notice.

"The Admiralty, after full consultation with the Treasury and Post Office, commenced negotiations with these two companies.

"They were influenced greatly by this consideration, that merchant vessels, when armed, to be really serviceable, should have exceptional speed and coal capacity, enabling them to overhaul the weak and to escape the strong.

"Such exceptional speed entails a primary cost in engines and boilers, and a consumption in coal that renders the remunerative employment of the vessel very difficult. Only a few of the richest and best-conducted passenger lines can afford to build such vessels, and the profits derived from their employment in recent years have been small.

"Unless some inducement is given by the English government to continue the building of such vessels,

they must diminish in number, whereas abroad, by subsidies, their construction is directly encouraged. It is neither to the credit of the country, nor for the advantage of our Marine, that vessels of this class should mostly be under foreign flags.

"The arrangement made with the two companies differs in detail, but is the same in principle.

"By the payment of an annual subsidy, reduced one-fourth so long as the mail contract lasts, the government obtain from the Cunard Company the use of the 'Aurania,' 'Etruria,' and 'Umbria,' in time of emergency at a price fixed both as regards hire or sale. The necessary platforms and fittings for carrying guns are to be put in at once; the crews of the ships to be half Naval reserve men; the owner to take charge of the gun mountings required. Under this arrangement, it is believed that within a week all these vessels could be fitted, armed, stored, and manned as armed cruisers. The use, at fixed prices, of the remainder of the fleet, if required, was a secondary condition of the contract.

"With the White Star the arrangement was practically the same, except that no payment was to be made till the two new ships to be built were ready for sea.

"By this arrangement the Admiralty have obtained, at a moderate annual cost, the use for five years of the three fastest steamers afloat, and two even faster, when constructed.

"Negotiations with the Australian colonies have for some time past been carried on, which though not concluded will, we hope, result in those countries contributing towards an extension of the Imperial Navy, and maintaining, as an integral part of the fleet, an

Australian squadron, in addition to the force which has hitherto been stationed in those waters.

"The rate of hire of the before-named vessels, of any or all, is fixed at the rate of 20 shillings per gross registered ton per month if the owner provides the crew, or at the rate of 15 shillings per gross registered ton if the Admiralty provide the crew. All risks of capture and of hostilities are assumed by the Admiralty. The company is to be allowed seven days' pay at the stipulated rate of hire, for any of the vessels chartered, for taking down cabin fittings not required by the Admiralty, and ten days on the same pay at the termination of the service for replacing those fittings, the work of dismounting, dismantling, and reinstating to be performed by the company at the expense of the Admiralty.

"Should the government hire, and subsequently elect to purchase any steamer under this agreement, three-eights of the amount of hire paid during the period, not exceeding six months immediately preceding the purchase, will be allowed by way of rebate from the amount of purchase-money provided by these presents.

"During the currency of this contract any vessels which may be substituted in the mail service for those before-named, except the steamers hereinafter referred to, shall also be subject to the like conditions as regards purchase and hire. In the event of purchase the price shall be fixed at the cost price to the company, with 10 per cent additional for compulsory sale, less an abatement in the manner previously provided.

"The Director of Naval Construction reports that the plans of these two proposed new vessels provide vessels far in advance of anything that has yet been

submitted to the Admiralty for the purpose of armed cruisers. They are to be of large size, of exceedingly high speed, provided with twin screws, have their engines and boilers placed below the water-line, be divided into numerous compartments, and have protected steering gear. They will be capable of conveying fully 2,000 men, whom they could land at Bombay via the Suez Canal in fourteen days, or via the Cape in twenty-two and one-half days. Their coal capacity will enable them to keep the sea for probably not less than three months.

"In order that the vessels receiving special subvention may be ready for service as armed cruisers at the shortest possible notice, the company shall afford the Admiralty every facility, compatible with the use of the vessels as mercantile ships, for placing on board during the construction of the steamers such permanent fittings and arrangements for their armament on approved plans as will enable them to be prepared for service within a week of arrival and discharge of cargo at Liverpool; and as regards the guns contemplated to be placed upon the upper deck, the Admiralty are to provide the racers and other fittings and gun mountings, which the company are to keep, if required, in their store-house at Liverpool without charge, ready for immediate placing in the ships at the cost of Admiralty, and to maintain the same in clean order for immediate use free of charge.

"One-half of the crews employed for these vessels shall consist, as nearly as possible, of men belonging to the Royal Naval reserve.

"Should any of the ships be sold to a British shipowner approved by the Admiralty, the privileges of this agreement remain attached to the ships under the new ownership.

"The price for the ships receiving the subvention is to be the cost price thereof, subject to the conditions for compulsory sale and abatement previously mentioned, but the Admiralty agree not to exercise their pre-emption, as regards purchase only, for two years after their completion.

"In order to have the ships ready for service as armed cruisers at the shortest possible notice, the company shall afford the Admiralty every facility compatible with their present use as mercantile ships for placing on board such fittings and arrangement for their armament as will enable them to be prepared within a week of their arrival at Liverpool and discharge of cargo. For this purpose the company consent to the Admiralty fitting the permanent supports and platforms for the four guns to be carried on the poop and forecastle.

"As regards these four guns and the eight guns contemplated to be placed on the upper deck, the Admiralty are to provide the racers and other fastenings and gun mountings, which the company are to keep stored, if required, without charge, ready for immediate placing in the ships at the cost of the Admiralty, and to maintain the same in clean order ready for immediate use free of charge.

"One-half of the men employed as the crews of these vessels are to be Royal Naval reserve men.

"Conditions of transfer to a British owner approved by Admiralty are the same as in contract with the White Star Company."

The final issue of all this is that practical measures have been taken by all governments to secure the services of such ships. A list of these ships is given at the end of this chapter. These ships bear the flags of different countries, but there is no national tie

whatever unless the ships are bound by contract and not even then unless the penalties are considerable. We have just seen a line of British steamers change nationality. There was nothing except the Postal Contracts to prevent the entire White Star Line for example from passing into the hands of a foreign power by the stroke of a pen in 1885, when the action was taken which Lord Brassey has described.

Those who find fault with that action have perhaps failed to notice that our fast mercantile marine is national only in name and that by notice given at the Custom House the whole of it might be transferred to another country in a few hours as the effect of a panic or of a money bargain.

When war threatens this must be a source of immediate anxiety if maritime operations are likely to be serious. The only way to prevent transfer of flag would be for the government to underwrite the insurance policies and allow the trade to continue at all risks. Or, if the insecurity of sailing-ships and slow steamers were too great and they had to be laid up then the state would have to take the burden by nominal purchase of the ships for an agreed time, paying interest to the owners on the nominal purchase money. One has only to remember the depredations which can be committed by a single fast steam-ship upon slow shipping to see how serious such a peril is.

Professor John Harvard Biles said at the Engineering Conference at the Institution of Civil Engineers in London in June, 1899:

"The two purposes for which merchant steamers may be used by the navy in time of war are: (1) armed cruisers; (2) auxiliaries for supplying a fleet with necessaries, and as troop transports.

"For the former purpose they may have to fight

cruisers; for the latter, they will frequently require protection from either armed mercantile cruisers or regular war-ships, but their ability to do the duty is undoubted, and need not be discussed.

"Obviously as armed cruisers vessels must have considerable speed, and their numbers are in consequence limited. Lloyd's give the following:—20 knots and upwards, 43; 19 knots and upwards, 35; 18 knots and upwards, 48; 17 knots and upwards, 83; 16 knots and upwards, 77; 15 knots and upwards, 128.

"Slower vessels will probably not be used as armed cruisers. Those speeds appear to be in most cases sea speeds. Some of the larger vessels have coal-bunker capacity, exclusive of holds, sufficient to enable them to steam for from 10,000 to 12,000 knots at 10 knots speed.

"We may reasonably assume that vessels of this character are better able to maintain their speed at sea than war-ships. Their every day business is to run at some speed called full speed, and most of them do not run at any other speed. It does not follow that they cannot steam easily at lower speeds, but a ship which ordinarily does not steam at full speed is more likely to fall short of maintaining full speed over long periods than one which is in the habit of doing it."

"In the recent Spanish-American war the cruisers 'St. Louis' and 'St. Paul,' 'New York' and 'Paris,' could steam at four knots, with the main throttle shut, by the use of the exhaust steam of the auxiliary engines only. About 30 tons per day is the necessary consumption on auxiliaries, and the exhaust steam was sufficient to propel the ship at four knots and keep the machinery ready for immediate increase of speed

to 20 knots. Eight minutes is the time given by the engineers to make this change.

"In consequence merchant ships have been considered to be most suitably used as scouts or despatch-boats, and no attempt has been made to give them an armament equivalent to war-ships of anything like their size, power, and speed. Some of the results of arming and fighting the mercantile cruisers of the United States navy seem to point to the ability of these vessels to cope with thoroughbred war-ships.

"One point is deserving of consideration. Is there not a considerable value in a floating structure, whether it is subdivided and protected as a war-ship, or has no more subdivision nor protection than a tramp? It floats, and it offers considerable resistance to sinking whatever kind of ship it is. Does not the result of modern sea-fighting point to the conclusion that a ship is more likely to be disabled by her crew being driven from their guns than from her being sunk from the effects of shell-fire? If this is so, the extra subdivision and protection of buoyancy and stability of a war-ship over a merchant-ship may not be called into play, and the fight between the two will become one of guns versus protection of gunners. This leads to the consideration of the question of portable protection for gunners in the merchant-ship.

"In the first-class cruisers, case-mates are built into the ships. These would be impracticable in a merchant-ship. But guns with shields are portable enough, and would place a merchant-ship in a very favourable position compared with a second-class cruiser, as her size and deck area allow her to mount a much larger number of guns. In a paper which I read in 1894 before the Institution of Naval Architects I

endeavoured to show how large mail-steamers could be made as fit to fight as many first-class cruisers. Portable side-armour was proposed, which should be ready for bolting on in time of war. If this system were adopted for the protection of guns, by placing them in a box-battery as the Americans have done and the Japanese are doing in the ship Mr. Dunn has designed for them at Barrow, a considerable number of guns could be mounted, which could be as well protected as in first-class cruisers. This subject is, however, too detailed to be discussed here, but it is not an impracticable operation to have portable armour put on a mail-steamer.

"The work done by the American line steamers in the recent war included scouting, drawing the fire of forts to discover their strength, cable cutting, troop, coal, and water carrying. All this work can be done by any vessels of high speed and large coal endurance, but it is worth discussing whether, having employed vessels valued at £100,000 to £500,000 each to do this work, it is not desirable to go a little further and make them able to do more by arming and protecting them so that they can meet second-class cruisers with the chances in their favour and with a fair chance of holding their own against a first-class cruiser. If they can, then the number of cruisers which will be available to protect our commercial routes may be much increased.

"The practicability of designing merchant-steamers so as to be readily adapted for war purposes has been discussed in the Institution of Naval Architects. The desirability is always a subject for discussion.

"The experience of recent wars points to the desirability of having vessels which can carry large coal and store cargoes, and which have facilities for readily transferring these cargoes to war-ships at sea.

This work could be well done by some of the large freight-carriers or liners which carry mails. Special appliances would have to be fitted to these vessels, which might or might not carry these appliances in their regular work. In the construction of these vessels special consideration might be given to their use for such purposes. Some large freight-carriers have ocean speeds of 15 knots, and such vessels would be of great service in time of war.

"A question arises in connection with the special and ordinary types of merchant-vessels as to their ability to carry guns. These vessels are generally constructed of scantlings much thicker than those of war-ships, and many places in their decks are amply strong enough to carry guns. Possibly some parts would require special strengthening, but this could be readily applied if necessary.

"In the matter of position of machinery in relation to the water-line, the later vessels of moderate and large size have their machinery and boilers not far, if anything, above the water-line.

"With a little consideration given to the question in the early stages of design and construction it is easy to arrange the structure so that the coal which these vessels carry will give protection. Twin-screw engines and increased revolutions are tending to make merchant-ships more safe in this respect.

"The principal point to note in connection with merchant-ships for war purposes is, that a ship of any kind offers considerable resistance to the destruction of its buoyancy and stability, and, in consequence, with guns and gunners sufficient and sufficiently protected, the merchant-ship need not be much, if at all, inferior to many war-ships."

At the close of the conference at the Royal United Service Institution following the lectures by M. de

Bloch on the lessons of the Transvaal War M. de Bloch said, on the question of maritime war, that he was of opinion that the protection of England's commerce would prevent fleet difficulties in time of war. The moral advantage of a larger fleet would not, he thought, be feared by a nation possessed of swift and powerful cruisers, against which battle-ships are useless. "In such a war speed determines everything, and in a war of commerce a weak nation which can put upon the seas a single cruiser which can steam one knot quicker than any of the enemy's ships may come out victorious."

It is the command of this single cruiser which the State will need. The way to get it, and the only way to get it, is to subsidise, generously, private shipbuilding enterprise. Each successive step in advance will then be taken in England, if she chooses; in the United States, probably, if England does not choose. Otherwise Germany will lead. The price of a war-cruiser taken in navy votes every year and allotted to subsidies would give us this great advantage.

ROYAL NAVAL RESERVED MERCHANT CRUISERS SUITABLE TO RECEIVE AN ARMAMENT.

Ship.	Owner.	Length.	I. H. P.	Ocean speed.
		Feet.		Knots.
"Campania"..	Cunard Co..............	610.0	30,000	21
"Lucania"....	Cunard Co..............	610.0	30,000	21
"Himalaya"..	Peninsular&OrientalCo.	465½	10,000	17
"Australia"..	Peninsular&OrientalCo.	465½	10,000	17
"Victoria"....	Peninsular&OrientalCo.	466	7,000	16
"Arcadia"....	Peninsular&OrientalCo.	466	7,000	16

* These speeds are given under the authority of Brassey's Naval Annual.

ROYAL NAVAL RESERVED MERCHANT CRUISERS SUITABLE TO RECEIVE AN ARMAMENT—*Continued*.

	Ship.	Owner.	Length. Feet.	I. H. P.	Ocean speed. Knots.
Twin screws.	"Majestic"	White Star Co..........	565	16,000	20*
	"Teutonic"	White Star Co..........	565	16,000	20*
	"Empress of India"...	Canadian Pacific Co.....	440	10,000	16
	"Empress of China"..	Canadian Pacific Co.....	440	10,000	16
	"Empress of Japan"..	Canadian Pacific Co.....	440	10,000	16
	"Etruria"....	Cunard Co..............	501½	14,500	19½
	"Umbria"....	Cunard Co..............	501½	14,500	19½
	"Servia".....	Cunard Co..............	515	10,000	16½
	"Aurania"...	Cunard Co..............	470	9,500	17
	"Britannic"..	White Star Co..........	455	5,200	16
	"Germanic"..	White Star Co..........	455	5,200	16
	"Cymric"....	White Star Co..........	455	6,700	16
	"Britannia"..	Peninsular&OrientalCo.	466	7,000	16
	"Oceana"....	Peninsular&OrientalCo.	466	6,000	16
	"Peninsular".	Peninsular&OrientalCo.	410½	4,972	15
	"Oriental"...	Peninsular&OrientalCo.	410½	4,972	15
	"Valetta"....	Peninsular&OrientalCo.	420½	5,000	15
	"Massilia"...	Peninsular&OrientalCo.	420½	5,000	15
	"Rome"......	Peninsular&OrientalCo.	430	5,500	15
	"Carthage"..	Peninsular&OrientalCo.	430	5,000	15
	"Ballarat"...	Peninsular&OrientalCo.	420	4,500	14
	"Paramatta"..	Peninsular&OrientalCo.	420	4,500	14

MERCHANT CRUISERS AUXILIARY TO FRENCH NAVY.†

Name.	Length.	Speed.
"La Touraine".....................	520 feet.	19 knots.
"Duc de Bragance"...............	334 "	17½ "
"Eugène Pereire".................	334 "	17½ "
"Général Chanzy"................	341 "	17½ "
"La Bretagne"....................	495 "	17½ "
"La Champagne".................	493 "	17½ "

*See page 191.
†Six ships 17½ to 20 knots speed have been added since this list was prepared.

MERCHANT CRUISERS AUXILIARY TO FRENCH NAVY—*Continued.*

Name.	Length.	Speed.
"La Gascogne"	495 feet.	17½ knots.
"Maréchal Bugeaud"	342 "	17½ "
"Ville d' Alger"	343 "	17½ "
"La Navarre"	471 "	17 "
"La Normandie"	459 "	16 "
"Ville de Tunis"	317 "	15½ "
"Moïse"	310 "	15 "
"St. Augustin"	314 "	15 "
"Versailles"	374 "	
"Ville de Madrid"	309 "	15 "
"Ville de Naples"	312 "	15 "
"Armand Béhic"	487 "	17½ "
"Australien"	482 "	17½ "
"Polynésien"	482 "	17½ "
"Ville de la Ciotat"	486 "	17½ "
"Ernest Simons"	442 "	17 "
"Indus"	446 "	17 "
"Brésil"	464 "	16½ "
"Chili"	463 "	16 "
"Cordillère"	463 "	16 "
"La Plata"	463 "	16½ "

MERCHANT CRUISERS AUXILIARY TO THE GERMAN NAVY.

Name.	Length.	Ocean Speed.
"Kaiser Wilhelm"	678 feet.	23 knots.
"Deutschland"	662 "	23 "
"Kronprinz Wilhelm"	640 "	23 "
"Kaiser Wilhelm der Grosse"	625 "	22 "
"Kaiser Friedrick III"	581 "	22 "
"Kaiser Friedrick"	581 "	19 "
"Kaiserin Maria Theresia"	526 "	20 "
"Augusta Victoria"	522 "	18 "
"Kiautschou"	522 "	16 "
"Fürst Bismarck"	502 "	19½ "
"Hamburg"	499 "	16 "
"Columbia"	461 "	19 "
"Lahn"	449 "	18½ "
"Aller"	436 "	16 "
"Trave"	436 "	16 "

MERCHANT STEAMERS AUXILIARY TO THE RUSSIAN NAVY.

Name.	Length.	Speed.
"Czar"	319 feet.	14 knots.
"Czarevna"	319 "	14 "
"Czaritza"	319 "	14 "
"Grand Duke Alexis"	284 "	16 "
"Grand Duke Constantine"	284 "	16 "
"Grand Duke No. 1"	288 "	14½ "
"Grand Duke No. 2"	288 "	14½ "
"Roumantzeff"	212 "	13 "
"Ekaterinoslav"	440 "	12 "
"Khabarovsk"	265 "	13 "
"Kherson"	493 "	19½ "
"Kiev"	440 "	13 "
"Kostroma"	360 "	14 "
"Moskva"	508 "	20 "
"Nijni Novgorod"	325 "	11½ "
"Orel"	445 "	19 "
"Petersburg"	460 "	19 "
"Poltava"	493 "	19½ "
"Saratoff"	462 "	19 "
"Smolensk"	506 "	20 "
"Tamboff"	385 "	12¾ "
"Vladimir"	440 "	12 "
"Voronej"	440 "	12 "
"Yaroslav"	385 "	12¾ "

MERCHANT STEAMERS AUXILIARY TO THE UNITED STATES NAVY.

Name.	Length.	I. H. P.	Speed.
"St. Louis"	535 feet.	18,000	22.2 knots.
"St. Paul"	535 "	18,000	22.5 "
"Paris"	517 "	20,000	20.7 "
"New York"	517 "	20,000	20.6 "
"Newport"	326 "	......	16 "
"City of Para"	345 "	2,250	12 "
"Caracas"	283 "	......	13 "
"Philadelphia"	300 "	......	12 "

MERCHANT STEAMERS AUXILIARY TO THE UNITED STATES NAVY—*Continued.*

Name.	Length.	I. H. P.	Speed.
"Venezuela"	303 feet.	......	....
"Orizaba"	336 "	......	14 knots.
"Yumuri"	336 "	......	14 "
"City of Washington"	300 "	......	15 "
"Saratoga"	298 "	......	14 "
"Seneca"	271 "	......	....
"Yucatan"	336 "	......	14 "
"Segurança"	321 "	......	14 "
"Vigilançia"	322 "	......	14 "
"Advance"	295 "	......	15 "
"Alliança"	303 "	2,250	14 "
"City of Sydney"	339 "	1,950	15 "
"City of Peking"	408 "	4,500	13 "
"City of Rio de Janeiro"	345 "	2,000	14 "
"Peru"	336 "	2,800	14 "

Six other vessels of from 290 to 250 feet in length.

Of converted merchant vessels retained in the navy there are six others of from 310 to 390 feet in length and of speeds between 13 and 16 knots.

CHAPTER XIX.

PRIVATE SHIPS IN THEIR RELATION TO BELLIGERENTS.

There are several questions which have received investigation and been brought near to settlement during the century in matters of International Maritime Law.

There are three of these of primary importance:

1. The law of contraband.
2. The rights of neutrals.
3. The liabilities of private unarmed ships under the belligerent flag.

1. Contraband is that which is contrary to Ban or Edict or Law. Goods that a neutral is prohibited by the laws of war to furnish to either belligerent such as arms, ammunition and military or naval supplies, such goods are contraband. But nothing can be justly regarded as contraband unless so regarded by the laws of nations or by express convention between certain parties.

The acknowledgment of this law of contraband implies a right of search by a belligerent. Lord Stowell said: "The right of visiting and searching ships on the high seas, whatever be the ships, whatever be the cargoes, whatever be the destinations is an incontestible right of the lawfully commissioned ship of a belligerent nation: because till they are visited and searched it does not appear what the ship or the cargoes or the destinations are: and it is for the

purpose of ascertaining these points that the necessity of this right of visitation and search exists. This right is so clear in principle that no man can deny it who admits the right of maritime capture, because if you are not at liberty to ascertain by sufficient enquiry whether there is property which can be legally captured, it is impossible to capture." The bombardment of Copenhagen in 1801 was one of the results of this policy. Sir Travers Twiss said in the *Encyclopædia Britannica* that apart from treaty the main rules that govern the right are as follows:

"It is a belligerent right and can be exercised only in time of war unless in the case of a vessel reasonably suspected of piracy or breach of revenue regulations.

"It can be exercised only by a ship of war duly commissioned by the sovereign of the belligerent power and only in the case of a merchant vessel, whether of an enemy or neutral power.

"It cannot be exercised in neutral waters, and an attempt to exercise it in such waters is a gross violation of neutrality.

"It can be exercised only for certain purposes such as to examine the ship's papers and to see whether she carries any contraband goods.

"After the ship of war has raised her flag an affirming gun loaded with blank cartridge must be fired to bring the merchant vessel to.

"In case of reasonable suspicion it is the duty of the ship of war to detain the merchant vessel for the decision of a prize court. Resistance by a neutral vessel, whether alone or in convoy, renders her liable to capture according to the English and United States doctrine.

"Most continental authorities lay down that the declaration of the officer in charge of the convoy is to

"be accepted, and that a refusal to accept such declaration may justify the convoy in resisting search. There is also a conflict of opinion as to whether a neutral loses his neutral rights by loading his goods on board of an armed ship of the enemy. It has been held in England that such a proceeding is a violation of neutrality, as affording a presumption of resistance to search."

The right of search says the writer above quoted is historically interesting as "on two occasions it has brought Great Britain into collision with the United States. One of the causes of the War of 1812 was the right then claimed (but since abandoned) by Great Britain of searching vessels of the United States for British subjects serving in them as seamen with a view of impressing them for the Royal Navy. In 1861 the British mail steamer 'Trent' was stopped on the high seas by a United States ship-of-war, and Messrs. Slidell and Mason, two commissioners of the Confederate States, proceeding to Europe, were taken out of her and afterwards imprisoned in the United States. On diplomatic representations being made at Washington by the ambassadors of Great Britain and other powers the commissioners were released and a war was avoided."

2. The rights of neutrals.

A great step was taken in 1856 in securing to neutrals the right to carry the goods of an enemy, except contraband of war, without liability to capture or the confiscation of the goods.

Private property not being contraband of war was thus secured against capture on the open seas by the neutral flag. No such right held if an attempt was made to enter a blockaded port.

The law runs as follows: (The author said in the article "Navy," *Encyclopædia Britannica.*)

In 1856 a most important event occurred seriously affecting this question, viz. the signing of what is known as the Declaration of Paris, a sort of rider to the treaty of Paris of March, 1856, by which declaration it was laid down that, "whereas it was formerly legal to grant royal commissions to private owners to equip, arm, and man private cruisers, to capture the commerce of the enemy for their own property, this shall no longer be legal; that, while the cruisers of the state may capture and destroy private ships belonging to subjects of the hostile state, they may not, as of old, search neutral ships in the open seas to discover and confiscate hostile property contained in them, but only to verify their right to fly the neutral flag, and to discover and confiscate property held to be contraband of war, destined for ports of the enemy."

The precise terms of the Declaration were as follows:—

1. Privateering is and remains abolished.

2. The neutral flag covers enemy's goods with the exception of contraband of war.

3. Neutral goods, with the exception of contraband of war, are not liable to capture under enemy's flag.

4. Blockades, in order to be binding, must be effective, that is to say, maintained by a force sufficient really to prevent access to the coast of the enemy.

3. Liabilities of private ships.

The history of the proceedings which led to the original declaration in 1854 by Great Britain and France is detailed in Vol. 12, Congress of United State 33, Session 1, 1853-4 by Mr. James Buchanan, then United States Minister in England. He takes considerable credit to himself for influence brought by him to bear on Lord Clarendon, before the British Cabinet decided to adopt the rule as to neutral ships.

He expressed the view which had been long taken by the United States government as to the doctrine that free ships should make free goods, a doctrine which England had never hitherto accepted.

There were probably other good influences at work behind the Throne in favour of lessening as much as possible the evils of war, and Englishmen who read the Queen's Proclamation of 1854 will be sure that they can see her own hand in it.

The Proclamation ran as follows:—

Her Majesty, the Queen of the United Kingdom of Great Britain and Ireland, having been compelled to take up arms in support of an ally is desirous of rendering the war as little onerous as possible to the Powers with which she remains at peace.

To preserve the commerce of neutrals from all unnecessary obstructions Her Majesty is willing, for the present, to waive a part of the belligerent rights appertaining to her by the law of nations.

It is impossible for Her Majesty to forego the exercise of her right of seizing articles contraband of war and of preventing neutrals from bearing enemy's despatches, and she must maintain the right of a belligerent to prevent neutrals from breaking any effective blockade which may be established with an adequate force against the enemy's forts, harbours or coasts.

But Her Majesty will waive the right of seizing enemy's property on board a neutral vessel unless it be contraband of war.

It is not Her Majesty's intention to claim the confiscation of neutral property, not being contraband of war, found on board enemies' ships and Her Majesty further declares that being anxious to lessen as much as possible the evils of war and to restrict its opera-

tions to the regularly organized forces of the country it is not her present intention to issue letters of Marque for the commissioning of privateers.

Westminster, March 28, 1854.

A similar communication was made by the Legations of France in the United States and in other countries on April 28, 1854.

It is this last clause affecting the interests of the private unarmed ships under the belligerent flag, a clause subsequently forming clause 1 of the Declaration of Paris, which we have now to consider.

Mr. Buchanan tells us that so far as his influence went it was against the course taken in suppressing privateering.

Mr. Buchanan in his conversation with Lord Clarendon on this subject learned that Lord Clarendon held a strong opinion against privateering as inconsistent with modern civilisation and liable to great abuses.

"I," says Mr. Buchanan, "admitted that the practice of privateering was subject to great abuses, but it did not seem to me to be possible under existing circumstances for the United States to agree to its suppression unless the Naval Powers would go one step further and consent that war against private property should be abolished altogether upon the ocean, as it had already been upon the land. There was nothing really different in principle or morality behind the act of a regular cruiser and that of a privateer in robbing a merchant vessel upon the ocean and confiscating the property of private individuals on board for the benefit of the captor.

"The genuine dictate of Christianity and civilisation would be to abolish war against private property upon the ocean altogether, and only to employ the

navies of the world in public warfare against the enemy, as their armies were now employed, and to this principle, thus extended, it was highly probable that the government of the United States would not object.

"The United States could not consent to abolish privateering under other circumstances. The only means which it would possess to counterbalance in some degree the far greater numerical strength of the navy of Great Britain, for example, would be to convert the merchant-vessels of the United States, cast out of employment by the war, into privateers and endeavour by their assistance to inflict as much injury on British as they would be able to inflict on American commerce."

Here then we have early in 1854 the position established which the United States government afterwards occupied and fortified by argument.*

Before passing on to those more extended arguments in favour of privateering it may be well to notice a fallacy underlying it.

In Mr. Buchanan's judgment the sailing-ships of the United States, which were excellent and abundant, would have formed the bulk of the privateers which she could have employed. Steam-ships had not then gone so far ahead of sailing-ships in speed as to make sailing-ships unavailable and it had not yet dawned on the political mind that steam would not only deprive sailing-ships of all value as privateers, but would also give to a very few ships absolute mastery over the great bulk of mercantile steam shipping.

*See Appendix to this chapter Mr. Marcy to Count Sartiges July 28, 1856.

If this could have been foreseen and the power of incorporating these few ships into the State navy realised, Mr. Buchanan would certainly have felt that he was resisting a great public good for the sake of a power, worth little at the moment, and which was rapidly vanishing.

All justification for privateering is gone when this condition of things is realised. The new principle has the immense advantage that the men who will fight in the subsidized cruisers are not private citizens, fighting for plunder, but public servants fighting for the rights of their country under the rules of war.

When in 1856 the question came up again at Paris, the plenipotentiaries who had signed the Treaty of Paris of 30th March, 1856, drew up the Declaration to which reference has been made embodying the four rules and said:

"That maritime law in time of war has been the subject of deplorable disputes; that the uncertainties of the law and of the duties in such a matter give rise to differences of opinion between neutrals and belligerents which may occasion serious difficulties and even conflicts, that it is consequently advantageous to establish a uniform doctrine in so important a point; that the plenipotentiaries assembled in congress at Paris cannot better respond to the intentions by which their governments are animated than by seeking to introduce into international relations fixed principles in this respect; the above-mentioned plenipotentiaries being duly authorized resolved to concert among themselves as to the means of attaining this object; and having come to an agreement have adopted the following solemn declaration;—

1. Privateering is and remains abolished, &c, &c;

The four rules already quoted, having been set forth, the document goes on:

"The governments of the undersigned plenipotentiaries engage to bring the present declaration to the knowledge of the States which have not taken part in the Congress of Paris and to invite them to accede to it.

"Convinced that the maxims which they now proclaim cannot but be received with gratitude by the whole world the undersigned plenipotentiaries doubt not that the efforts of their governments to obtain the general adoption thereof will be crowned with full success.

"The present Declaration is not and shall not be binding except between those Powers who have acceded and shall accede to it.

"Done at Paris the sixteenth of April, One thousand Eight hundred and fifty-six."

Unfortunately for the world the United States, usually a leader in good things, was to adopt the position and the fallacy of Mr. Buchanan taken in 1854, and, as we shall see, was to allow Mr. Buchanan himself, a little later, as President elect of the United States to haul down with his own hands the flag he had hoisted in 1854 for the wider measure of relief of merchant-ships from capture and injury in war.

But for that act on the part of President Buchanan in April, 1857, the proposal of the President of the United States for the amendment of clause 1 of the Declaration of Paris made before the Senate, August 12, 1856, "that the private property of the subjects or citizens of a belligerent on the high seas shall be exempted from seizure by public armed vessels of the

other belligerent except it be contraband"—this proposal would, the Author believes, have been now universally accepted.

On Nov. 24, 1856, Mr. Marcy had received at Washington a dispatch from Mr. Mason at Paris declaring that the Imperial government of France would accept the amendment and adding Russia has already done so, and several other powers have received it with favour. Mr. Marcy says, "If there is strenuous resistance in any quarter it will come from England."

But England had offered no such resistance when in April, 1857, President Buchanan caused the British government to be notified that the United States would be pleased to consider the negotiations suspended.

The actual situation is shewn by the following State papers:

Mr. Dallas to the Earl of Clarendon.

Legation of the United States, London,
February 24, 1857.

"WITH reference to the interview at the Foreign Office on the 20th instant, the Undersigned, Envoy Extraordinary and Minister Plenipotentiary of the United States, has now the honour to submit to the Earl of Clarendon, Her Majesty's Principal Secretary of State for Foreign Affairs, the accompanying draft of a Convention, declaratory of certain principles of maritime law, to the adoption of which he has been specially instructed to invite Her Majesty's Government.

"The Plenipotentiaries of Great Britain, Austria, France, Prussia, Russia, Sardinia, and Turkey, while

assembled in Congress at Paris on the 16th of April, 1856, having taken into consideration the subject of maritime law in time of war, agreed to a Declaration containing the following four 'maxims':—

"1. Privateering is, and remains, abolished.

"2. The neutral flag covers enemy's goods, with the exception of contraband of war.

"3. Neutral goods, with the exception of contraband of war, are not liable to capture under enemy's flag.

"4. Blockades, in order to be binding, must be effective; that is to say, maintained by a force sufficient really to prevent access to the coast of the enemy.

"The Plenipotentiaries also engaged that their respective Governments should bring this Declaration to the knowledge of the States which had not taken part in the Congress of Paris, and invite them to accede to it; and added, that it was not and should not be binding, except between those Powers who have acceded, or shall accede, to it.

"To the United States the above-mentioned Declaration has been formally made known by several of the Governments whose Plenipotentiaries subscribed it (though not by Her Majesty's Government), and their adhesion invited.

"These four principles of international relation have long engaged the consideration of the American Government. About two years prior to the meeting of the Congress at Paris, negotiations had been originated, and were in train, with the maritime nations for the adoption of the second and third propositions, substantially as enunciated in the Declaration. The fourth of those principles, respecting blockade, had, it is believed, long since become a fixed rule of the law of war. And, in relation to the first

of those principles, contemplating, in deference to the higher civilization and purer philanthropy of the age, a general relinquishment of a right undoubtedly possessed by every nation—that of employing private armed vessels against an enemy—the President of the United States had publicly, in his Message to Congress at the opening of the session in December, 1854, expressed the policy and sentiment of the American Government and people.

"To all of the propositions of the Declaration made by the Plenipotentiaries at Paris, the Government of the United States has been, therefore, for some time, and still is, prepared cordially to accede, excepting only with such an addition to the first as has always seemed to the President indispensable to the attainment of its true and humane purpose—that of diminishing the calamities of war.

"The Undersigned forbears, in this communication, to press upon the Earl of Clarendon the reasons which brought the Government of the United States to the conviction that the enlargement of the first proposition in the Declaration of the Plenipotentiaries at Paris, as made in the accompanying draft of a Convention, is necessary before that proposition can justly claim its assent. Those reasons have been distinctly and fully stated in various executive and international Papers, which have doubtless heretofore reached his Lordship's notice. They arise, indeed, naturally, in any deliberative mind, by which the relinquishment of the right to employ privateers is considered in its bearing upon the Constitutional structure, the economical policy, the commercial activity, and the defensive means of the United States.

"It is undoubtedly true that some incongruity may be detected in comparing the second and third prop-

ositions with the first of the furnished draft; but it has been thought most prudent to abstain from any effort to improve the form of the Convention by changing the phraseology employed by the Plenipotentiaries at Paris, or by the American Executive. The respective propositions, thus worded, have been addressed to and reflected upon by maritime nations generally, and much delay and inconvenience would necessarily be consequent upon moulding them anew. If Her Majesty's Government be disposed to concur in the principles themselves, it is not presumed that an objection will be suggested by the mere form in which they are embodied.

"The Undersigned is directed to invite Her Majesty's Government to conclude the proposed Convention; and he has the honour to apprise the Earl of Clarendon that the President of the United States has transmitted him a full power to negotiate and sign it whenever agreed upon.

"The Undersigned, &c.

"(Signed) G. M. DALLAS.

Inclosure in Above.

"A TREATY, &c.

"The United States of America and

animated by a common desire to render more intimate the relations of friendship and good understanding now so happily subsisting between them, and more especially to establish these relations in accordance with the present state and progress of civilization, have mutually resolved to declare, by means of a

formal Convention, the principles of Maritime Law which the High Contracting Parties acknowledge as the basis of neutral and belligerent rights at sea, and which they agree to recognize as permanent and immutable, and to observe between themselves and with other Powers which shall recognize and observe the same towards the Parties to this Convention.

"For this purpose, the President of the United States has conferred full powers on

and

has conferred like powers on

and said Plenipotentiaries, after having exchanged their full powers, found in good and due form, have concluded and signed the following Articles:—

ARTICLE I.

"The High Contracting Parties do hereby agree to observe the following principles as immutable rules of Maritime Law:—

"First. That privateering is, and shall remain, abolished, and the private property of subjects or citizens of a belligerent, on the high seas, shall be exempted from seizure by the public armed vessels of the other belligerent, except it be contraband.

"Second. The neutral flag covers enemy's goods, with the exception of contraband of war.

"Third. Neutral goods, with the exception of contraband of war, are not liable to capture under enemy's flag.

"Fourth. Blockades, in order to be binding, must be effective; that is to say, maintained by a force

sufficient really to prevent access to the coast of the enemy.

ARTICLE II.

"The High Contracting Parties do hereby declare that, henceforward, in judging of the rights of citizens and subjects of neutral nations, they will observe the principles contained in the foregoing Articles, and be guided by them, and that all nations which shall stipulate by Treaty to accede to the aforesaid principles, and observe the same, shall enjoy the rights secured thereby as fully as the two Powers signing this Convention.

"This Convention shall be ratified by the President of the United States, by and with the advice and consent of the Senate thereof and by
and the ratifications shall be exchanged at
within fifteen months, to be counted from the date of the signature hereof, or sooner, if possible.

Mr. Dallas to the Earl of Clarendon.—(Received April 27.)

Legation of the United States, London,
April 25, 1857.

"THE Undersigned, Envoy Extraordinary and Minister Plenipotentiary of the United States, referring to his letter of the 24th of February, 1857, relating to a modification of the rules of maritime law which were proposed by the Conference at Paris, has the honour to inform the Earl of Clarendon, Her Majesty's Principal Secretary of State for Foreign Affairs, that he has recently been specially instructed

by his Government to suspend negotiations upon that subject until he shall have received further instructions.

"The Undersigned, &c.

"(Signed) G. M. DALLAS."

Mr. Stark, an American writer,* tells us that seeing the difference between the action of James Buchanan the minister and President Buchanan it was thought that he meant to propose an amendment to the amendment of President Pierce, which he had thus withdrawn, by which amendment he would have proposed to go further and abolish commercial blockades as there had been some considerable public feeling in America in favour of this greater relief to commerce during maritime war. "But," says Mr. Stark, "unfortunately he never did and the United States remained outside the pale of the Declaration of Paris at the outbreak of the Civil War in 1861."

"When," says Mr. Stark, "the Civil War broke out in the United States and the government at Richmond announced its intention to issue letters of marque the greatest consternation was produced in the North. It was reflected that had the United States acceded to the Declaration of Paris the Southern States, then certainly part of the Union, would have been bound to it and we might justly have invoked the assistance of foreign nations to prevent its violation. As it was the immense commerce of the North was exposed and there was no way of retaliating on the Southerners by sea." The United States government at this date approached the governments

* *Abolition of Privateering and Declaration of Paris. Columbia Press*, New York, 1897.

of Great Britain and of France for the purpose of joining in the Declaration of Paris in the hope that it might gain an advantage diplomatically over the South. When it was seen that France and Great Britain would not lend themselves to this the proposal was dropped."

(See Parliamentary Papers, North America 3, entitled "Correspondence concerning International Maritime Law," presented to Parliament 1862.)

In the course of this later correspondence Lord John Russell had taken the place of Lord Clarendon. It had been seen that there was a feeling in the United States that the proposal of the President of the United States in 1857, following on the earlier proposals of 1856, was insufficient so long as commercial blockades remained possible; and it was remembered that the United States proposals had been withdrawn without explanation while they were under consideration in England.

It is not therefore surprising, although it is much to be regretted, that an opinion was expressed by Great Britain against the amendment of the United States and in favour of the continued liability of peaceful merchant-ships to capture by the regular war cruisers of a belligerent.

On June 12, 1861, Lord John Russell, writing to the British Legation in Paris, said:

Lord J. Russell to Mr. Grey.

"Sir, *Foreign Office, June 12, 1861.*

THE Ambassador of France came to me yesterday, and informed me that the Minister of the United States at Paris had made to M. Thouvenel two propositions,

The first was that France should agree to add to the 1st Article of the Declaration of Paris the plan of protecting private property on the sea from capture in time of war.

The second proposition was, that privateering being abolished by the adoption of the 1st Article of the Declaration of Paris, amended as proposed, the privateers sent out by the so-styled Southern Confederacy should be considered as pirates.

M. Thouvenel wishes to learn the opinions of Her Majesty's Government upon these propositions. Her Majesty's Government decidedly object to the first proposition. It seems to them that it would reduce the power in time of war of all States having a military as well as a commercial marine.

It is hardly necessary to point out that in practice it would be almost impossible to distinguish between *bona fide* ships carrying merchandize, and ships fraudulently fitted out with means of war under the guise of merchant-vessels.

With regard to the second point, Her Majesty's Government are not disposed to depart from the neutral character which Her Majesty, as well as the Emperor of the French, has assumed.

You will read this despatch to M. Thouvenel.

I am, &c.

(Signed) J. RUSSELL."

In reply Mr. Grey wrote:

Mr. Grey to Lord J. Russell.—(Received June 15.)

"My Lord, *Paris, June 14, 1861.*

IN obedience to your Lordship's instructions, I, yesterday, read to M. Thouvenel your despatch of the

12th instant, relating to the propositions made by the Minister of the United States to his Excellency.

M. Thouvenel expressed great satisfaction on finding how completely your Lordship's views coincided with his own. His Excellency said he was already aware that your Lordship entertained the same opinion as he himself did on this subject, but he had not yet heard it so decidedly expressed, and he desired me to convey his thanks to your Lordship for the communication.

His Excellency proceeded to say that the first proposition had not been made by Mr. Dayton until he had asked that Minister to address him an official note on the subject. His answer to it was that the Imperial Government would be glad if that of the United States acceded 'purely and simply' to the Declaration of Paris, but that it was out of the question to accept the condition which it was proposed to add to that Declaration, for the effect would be, as your Lordship observes, greatly to reduce the power in time of war of all States having a military as well as a commercial marine. With regard to the second proposition, his Excellency said it was made by the United States with the evident object of leading the French Government to take a decided part against the Southern Confederacy, but this attempt had failed, and there was no intention on the part of the French Government to depart from their neutral character.

M. Thouvenel also informed me that he has not yet received any further communication from Mr. Dayton.

I have, &c.

(Signed) W. G. GREY."

The United States favoured the capture of com-

merce by ships under letters of marque because otherwise they said, weak powers would be unable to equip efficient cruisers and they would suffer as against strong navies. The fallacy was, as has been said, not then apparent because steam and high steam speeds had not given to one hundredth part of the mercantile marine overwhelming advantages beyond those possessed by the remaining ninety-nine parts.

The purely commercial Marine, according to the American view, wants to arm its ships under letters of marque that it may be able to harry the commerce of the State having a military as well as a commercial marine. The latter, according to the British view, wishes to send its war cruisers against the commerce of the former in order to be able to take advantage of its military marine.

If the latter had not a large military marine, privateering would have been given up by the former (the purely commercial marine); so also, according to Lord John Russell, would the capture of commerce by war cruisers. It is thus according to these authorities the mere existence of the large military marine, and not the growth of the mercantile marine and the responsibility resulting from it, which keeps up the liabilities of commerce at sea to losses not paralleled on the land and which will spread such useless disaster.

It is therefore to the military powers that the world must look to give much needed relief to humanity at large and to the burdened tax payers of the military powers in particular.

Great Britain alone, or with France, could at any moment reopen the negotiations with the United States which were suspended in 1857.

If the proposed Convention of Feb. 24, 1857, were adopted by the representatives of the powers which

made the Declaration of 1856 an immense influence for the promotion of good understanding among the nations would be created.

These powers would now be Great Britain, Austria, France, Germany, Russia, Italy and Turkey, and to them would be added the original promoter of the policy—the United States of America.

Great Britain is now in the position that she insists on the maintenance of the right to capture merchant ships by her ships of war because otherwise she could not use her full strength as a military power on the sea. She alleges also that the only reason why she creates a military navy so large as to excite the fears of her neighbours is because her merchant ships are liable to capture. Truly a strange position if she does not desire to create fears and jealousies.

The only other reason given by Lord John Russell for refusing to exclude merchant ships from capture and confiscation by war cruisers was that "it would be almost impossible to distinguish between *bonâ fide* ships carrying merchandise and ships fraudulently fitted out with means of war under the guise of merchant vessels."

Seeing that belligerents would retain the right of search how can it be supposed that disguised armed ships could avoid detection and capture?

In the treatise by M. Charles Dupuis *Le Droit de la Guerre Maritime* (Paris A. Pedone, 1899) the case is argued out very fully. There are two paragraphs which represent, according to him, the British view of the value of the right to capture private ships, and what he thinks should be the continental view. Both are in favour of the retention of the right, but for absolutely contradictory reasons. The British reason is, he says, that it is to her advantage. "*L'Angle-*

terre, de son côté, est convaincue que le droit de prise a été, eu cours des grandes guerres maritimes du XVIII^e Siècle et de la période napoléonieune, la cause du développement de sa marine, la source de sa prépondérance commerciale. Elle lui attribue cette suprématie sur les mers qui était assurément pour elle, le but principal de la lutte."

The reason which should operate with the continental powers is that the continuance of this maritime practice is to the grave disadvantage of Great Britain. "*Des puissances insulaires*" he says "*telles que l', Angleterre ou le Japon ou des États comme les Etats-Unis d' Amérique, dans une guerre avec une puissance dont l' Océan les separe, seraient pratiquement invulnérables. Il serait chimérique d'en appeler a la force pour redresser les torts que leur seraient imputables.*"

APPENDIX TO CHAPTER XIX.

Mr. Marcy to Count De Sartiges.

Department of State, Washington,
July 28, 1856.

THE Undersigned, Secretary of State of the United States, has laid before the President "The Declaration concerning Maritime Law," adopted by the Plenipotentiaries of Great Britain, Austria, France, Prussia, Russia, Sardinia, and Turkey, at Paris, on the 16th of April, 1856, which the Count de Sartiges, Envoy Extraordinary and Minister Plenipotentiary of France, has presented on behalf of the Emperor of the French to the Government of the United States, for the purpose of obtaining its adhesion to the principles therein contained.

Nearly two years since, the President submitted, not only to the Powers represented in the late Congress at Paris, but to all other maritime nations, the second and third propositions contained in that Declaration, and asked their assent to them as permanent principles of international law. The propositions thus submitted by the President were:—

"1. That free ships make free goods—that is to say, that the effects or goods belonging to subjects or citizens of a Power or State at war are free from capture and confiscation when found on board of neutral vessels, with the exception of articles contraband of war.

"2. That the property of neutrals on board an enemy's vessel is not subject to confiscation unless the same be contraband of war."

It will be perceived that these propositions are substantially the same as the second and third in the Declaration of the Congress at Paris.

Four of the Governments with which negotiations were opened on the subject by the United States have signified their acceptance of the foregoing propositions. Others were inclined to defer acting on them until the return of peace should furnish a more auspicious time for considering such international questions. The proceeding of the Congress of the Plenipotentiaries at Paris will, as a necessary consequence, defeat the pending negotiations with the United States, if the two following propositions, contained in Protocol No. 24, are acceded to:—1st, that the four principles shall be indivisible; and 2nd, that the Powers which have signed or may accede to the Declaration shall not enter into any arrangement in regard to the application of the right of neutrals in time of war which does not at the same time rest on the four principles which are the object of said Declaration. As the indivisibility of the four principles, and the limitation upon the sovereign attribute of negotiating with other Powers, are not a part of the Declaration, any nation is at liberty to reject either, or both, and to act upon the Declaration without restriction, acceding to it in whole or in part. In deliberating on this important subject, it behooves all Powers to consider, and, if they think proper, to act upon this distinction. All the Powers which may accede to that Declaration, and the subsequent restrictions contained in the 24th Protocol, will assume an obligation which takes from them the liberty of assenting to the

propositions submitted to them by the United States, unless they at the same time surrender a principle of maritime law which has never been contested—the right to employ privateers in time of war.

The second and third principles set forth in the Declaration, being those submitted to other maritime Powers for adoption by this Government, it is most anxious to see incorporated, by general consent, into the code of maritime law, and thus placed beyond future controversy or question. Such a result, securing so many advantages to the commerce of neutral nations, might have been reasonably expected, but for the proceedings of the Congress at Paris, which require them to be purchased by a too costly sacrifice—the surrender of a right which may well be considered as essential to the freedom of the seas.

The fourth principle contained in the Declaration, namely, "Blockades, in order to be binding, must be effective; that is to say, maintained by a force sufficient really to prevent access to the coast of the enemy," can hardly be regarded as one falling within that class with which it was the object of the Congress to interfere; for this rule has not, for a long time, been regarded as uncertain, or the cause of any "deplorable disputes." If there have been any disputes in regard to blockades, the uncertainty was about the facts, but not the law. Those nations which have resorted to what are properly denominated "paper blockades" have rarely, if ever, undertaken afterwards to justify their conduct upon principle, but have generally admitted the illegality of the practice, and indemnified the injured parties. What is to be judged "a force sufficient really to prevent access to the coast of the enemy," has often been a severely-contested question; and certainly the Declaration,

which merely reiterates a general undisputed maxim of maritime law, does nothing towards relieving the subject of blockade from that embarrassment. What force is requisite to constitute an effective blockade remains as unsettled and as questionable as it was before the Congress at Paris adopted the Declaration.

In regard to the right to employ privateers, which is declared to be abolished by the first principle put forth in the Declaration, there was, if possible, less uncertainty. The right to resort to privateers is as clear as the right to use public armed ships, and as incontestable as any other right appertaining to belligerents. The policy of that law has been occasionally questioned, not, however, by the best authorities; but the law itself has been universally admitted, and most nations have not hesitated to avail themselves of it; it is as well sustained by practice and public opinion as any other to be found in the Maritime Code.

There is scarcely any rule of international law which particular nations in their Treaties have not occasionally suspended or modified in regard to its application to themselves. Two Treaties only can be found in which the Contracting Parties have agreed to abstain from the employment of privateers in case of war between them. The first was a Treaty between the King of Sweden and the States-General of the United Provinces, in 1675. Shortly after it was concluded the parties were involved in war, and the stipulation concerning privateers was entirely disregarded by both. The second was the Treaty of 1785, between the United States and the King of Prussia. When this Treaty was renewed in 1799, the clause stipulating not to resort to privateering was omitted. For the last half century there has been no arrangement, by Treaty or otherwise, to abolish

the right, until the recent proceedings of the Plenipotentiaries at Paris.

By taking the subject of privateering into consideration, that Congress has gone beyond its professed object, which was, as it declared, to remove the uncertainty on points of maritime law, and thereby prevent "differences of opinion between neutrals and belligerents, and consequently serious difficulties and even conflicts." So far as the principle in regard to privateering is concerned, the proceedings of the Congress are in the nature of an act of legislation, and seek to change a well-settled principle of international law.

The interest of commerce is deeply concerned in the establishment of the two principles which the United States had submitted to all maritime Powers; and it is much to be regretted that the Powers represented in the Congress at Paris, fully approving them, should have endangered their adoption by uniting them to another inadmissible principle, and making the failure of all the necessary consequence of the rejection of any one. To three of the four principles contained in the Declaration there would not probably be a serious objection from any quarter, but to the other a vigorous resistance must have been anticipated.

The policy of the law which allows a resort to privateers has been questioned for reasons which do not command the assent of this Government. Without entering into a full discussion on this point, the Undersigned will confront the ordinary and chief objection to that policy, by an authority which will be regarded with profound respect, particularly in France. In a commentary on the French Ordonnance of 1681, Valin says:—

"However lawful and time-honoured this mode of

warfare may be, it is, nevertheless, disapproved of by some pretended philosophers. According to their notions, such is not the way in which the State and the Sovereign are to be served: whilst the profits which individuals may derive from the pursuit are illicit, or at least disgraceful. But this is the language of bad citizens, who, under the stately mask of a spurious wisdom, and of a crafty, sensitive conscience, seek to mislead the judgment by a concealment of the secret motive which gives birth to their indifference for the welfare and advantage of the State. Such are as worthy of blame as are those entitled to praise who generously expose their property and their lives to the dangers of privateering."

In a work of much repute published in France almost simultaneously with the proceedings of the Congress at Paris, it is declared that—"The issuing of letters of marque, therefore, is a constantly customary belligerent act. Privateers are *bona fide* war-vessels, manned by volunteers, to whom, by way of reward, the Sovereign resigns such prizes as they make, in the same manner as he sometimes assigns to the land forces a portion of the war contributions levied on the conquered enemy."—(Pistoye et Duverdy, *Des Prises Maritimes.*)

It is not denied that annoyances to neutral commerce, and even abuses, have occasionally resulted from the practice of privateering; such was the case formerly more than in recent times: but when it is a question of changing a law, the incidental evils are to be considered in connection with its benefits and advantages. If these benefits and advantages can be obtained in any other way, without injury to other rights, these occasional abuses may then justify the

change, however ancient or firmly established may be the law.

The reasons which induced the Congress of Paris to declare privateering abolished are not stated, but they are presumed to be only such as are usually urged against the exercise of that belligerent right.

The prevalence of Christianity and the progress of civilization have greatly mitigated the severity of the ancient mode of prosecuting hostilities. War is now an affair of Governments. "It is the public authority which makes and carries on war; individuals are not permitted to take part in it, unless authorized to do so by their Government." It is a generally received rule of modern warfare, so far at least as operations upon land are concerned, that the persons and effects of non-combatants are to be respected. The wanton pillage or uncompensated appropriation of individual property by an army, even in possession of an enemy's country, is against the usage of modern times. Such a mode of proceeding at this day would be condemned by the enlightened judgment of the world, unless warranted by special circumstances. Every consideration which upholds this sentiment in regard to the conduct of a war on land favours the application of the same rule to the persons and property of citizens of the belligerents found upon the ocean.

It is fair to presume that the strong desire to ameliorate the severe usages of war by exempting private property upon the ocean from hostile seizure, to the extent it is usually exempted on land, was the chief inducement, which led to the Declaration by the Congress at Paris, that "privateering is and remains abolished."

The Undersigned is directed by the President to

say, that to this principle of exempting private property upon the ocean, as well as upon the land, applied without restriction, he yields a most ready and willing assent. The Undersigned cannot better express the President's views upon the subject than by quoting the language of his annual Message to Congress, of December 4, 1854:—

"The proposition to enter into engagements to forego a resort to privateers, in case this country should be forced into a war with a great naval Power, is not entitled to more favourable consideration than would be a proposition to agree not to accept the services of volunteers for operations on land. When the honour or rights of our country require it to assume a hostile attitude, it confidently relies upon the patriotism of its citizens, not ordinarily devoted to the military profession, to augment the army and navy, so as to make them fully adequate to the emergency which calls them into action. The proposal to surrender the right to employ privateers is professedly founded upon the principle that private property of unoffending non-combatants, though enemies, should be exempt from the ravages of war; but the proposed surrender goes but little way in carrying out that principle, which equally requires that such private property should not be seized or molested by national ships of war. Should the leading Powers of Europe concur in proposing, as a rule of international law, to exempt private property, upon the ocean, from seizure by public armed cruizers as well as by privateers, the United States will readily meet them upon that broad ground."

The reasons in favour of the doctrine that private property should be exempted from seizure in the operations of war are considered in this enlightened

age so controlling as to have secured its partial adoption by all civilized nations; but it would be difficult to find any substantial reasons for the distinction now recognized in its application to such property on land, and not to that which is found upon the ocean.

If it be the object of the Declaration adopted at Paris to abolish this distinction, and to give the same security from the ravages of war to the property of belligerent subjects on the ocean as is now accorded to such property on the land, the Congress at Paris has fallen short of the proposed result, by not placing individual effects of belligerents beyond the reach of public armed ships as well as privateers. If such property is to remain exposed to seizure by ships belonging to the navy of the adverse party, it is extremely difficult to perceive why it should not, in like manner, be exposed to seizure by privateers, which are, in fact, but another branch of the public force of the nation commissioning them.

If the principle of capturing private property on the ocean and condemning it as prize of war be given up, that property would, and of right ought to be, as secure from molestation by public armed vessels as by privateers; but if that principle be adhered to, it would be worse than useless to attempt to confine the exercise of the right of capture to any particular description of the public force of the belligerents. There is no sound principle by which such a distinction can be sustained; no capacity which could trace a definite line of separation proposed to be made; and no proper tribunal to which a disputed question on that subject could be referred for adjustment. The pretence that the distinction may be supported upon the ground that ships not belonging permanently to a regular navy are more likely to disregard the rights

of neutrals than those which do belong to such a navy is not well sustained by modern experience. If it be urged that a participation in the prizes is calculated to stimulate cupidity, that, as a peculiar objection, is removed by the fact that the same passion is addressed by the distribution of prize-money among the officers and crews of ships of a regular navy. Every nation which authorizes privateers is as responsible for their conduct as it is for that of its navy, and will, as a matter of prudence, take proper precaution and security against abuses.

But if such a distinction were to be attempted, it would be very difficult, if not impracticable, to define the particular class of the public maritime force which should be regarded as privateers. "Deplorable disputes," more in number and more difficult of adjustment, would arise from an attempt to discriminate between privateers and public armed ships.

If such a discrimination were attempted, every nation would have an undoubted right to declare what vessels should constitute its navy, and what should be requisite to give them the character of public armed ships. These are matters which could not be safely or prudently left to the determination or supervision of any foreign Power, yet the decision of such controversies would naturally fall into the hands of predominant naval Powers, which would have the ability to enforce their judgments. It cannot be offensive to urge weaker Powers to avoid as far as possible such an arbitrament, and to maintain with firmness every existing barrier against encroachments from such a quarter.

No nation which has a due sense of self-respect will allow any other, belligerent or neutral, to determine the character of the force which it may deem proper

to use in prosecuting hostilities; nor will it act wisely if it voluntarily surrenders the right to resort to any means, sanctioned by international law, which, under any circumstances, may be advantageously used for defence or aggression.

The United States consider powerful navies and large standing armies, as permanent establishments, to be detrimental to national prosperity and dangerous to civil liberty. The expense of keeping them up is burdensome to the people; they are, in the opinion of this Government, in some degree a menace to peace among nations. A large force, ever ready to be devoted to the purposes of war, is a temptation to rush into it. The policy of the United States has ever been, and never more than now, adverse to such establishments; and they can never be brought to acquiesce in any change in international law which may render it necessary for them to maintain a powerful navy or large regular army in time of peace. If forced to vindicate their rights by arms, they are content, in the present aspect of international relations, to rely, in military operations on land, mainly upon volunteer troops, and for the protection of their commerce in no inconsiderable degree upon their mercantile marine. If this country were deprived of these resources, it would be obliged to change its policy, and assume a military attitude before the world. In resisting an attempt to change the existing maritime law that may produce such a result, it looks beyond its own interest, and embraces in its view the interest of all such nations as are not likely to be dominant naval Powers. Their situation in this respect is similar to that of the United States, and to them the protection of commerce, and the maintenance of international relations of peace, appeal as strongly as to this country, to with-

stand the proposed change in the settled Law of Nations. To such nations, the surrender of the right to resort to privateers would be attended with consequences most adverse to their commercial prosperity, without any compensating advantages. Most certainly no better reasons can be given for such a surrender than for foregoing the right to receive the services of volunteers; and the proposition to abandon the former is entitled, in the judgment of the President, to no more favour than a similar proposition in relation to the latter. This opinion of the importance of privateers to the community of nations, excepting only those of great naval strength, is not only vindicated by history, but sustained by high authority. The following passage in the Treatise on maritime prizes to which I have before referred, deserves particular attention:—

"Privateers are especially useful to those Powers whose navy is inferior to that of their enemies. Belligerents, with powerful and extensive naval armaments, may cruize upon the seas with their national navies; but should those States whose naval forces are of less power and extent be left to their own resources, they could not hold out in a maritime war; whilst by the equipment of privateers they may succeed in inflicting upon the enemy an injury equivalent to that which they themselves sustain. Hence Governments have frequently been known, by every possible appliance, to favour privateering armaments. It has even occurred that Sovereigns, not merely satisfied with issuing letters of marque, have also taken, as it were, an interest in the armament. Thus did Louis XIV frequently lend out his ships, and sometimes reserve for himself a share in the prizes."

It certainly ought not to excite the least surprise

that strong naval Powers should be willing to forego the practice, comparatively useless to them, of employing privateers, upon condition that weaker Powers agree to part with their most effective means of defending their maritime rights. It is, in the opinion of this Government, to be seriously apprehended that if the use of privateers be abandoned, the dominion over the seas will be surrendered to those Powers which adopt the policy and have the means of keeping up large navies. The one which has a decided naval superiority would be potentially the mistress of the ocean, and by the abolition of privateering that domination would be more firmly secured. Such a Power engaged in war with a nation inferior in naval strength would have nothing to do for the security and protection of its commerce but to look after the ships of the regular navy of its enemy. These might be held in check by one-half, or less, of its naval force, and the other might sweep the commerce of its enemy from the ocean. Nor would the injurious effects of a vast naval superiority to weaker States be much diminished if that superiority was shared among three or four great Powers. It is unquestionably the interest of such weaker States to discountenance and resist a measure which fosters the growth of regular naval establishments.

In discussing the effect of the proposed measure—the abolition of privateering—a reference to the existing condition of nations is almost unavoidable. An instance will at once present itself in regard to two nations where the commerce of each is about equal, and about equally wide-spread over the world. As commercial Powers they approach to an equality, but as naval Powers there is great disparity between them. The regular navy of one vastly exceeds that

of the other. In case of a war between them, only an inconsiderable part of the navy of the one would be required to prevent that of the other from being used for defence or aggression, while the remainder would be devoted to the unembarrassed employment of destroying the commerce of the weaker in naval strength. The fatal consequences of this great inequality of naval force between two such belligerents would be in part remedied by the use of privateers; in that case, while either might assail the commerce of the other in every sea, they would be obliged to distribute and employ their respective navies in the work of protection. This statement only illustrates what would be the case, with some modification, in every war where there may be considerable disparity in the naval strength of the belligerents.

History throws much light upon this question. France, at an early period, was without a navy, and in her wars with Great Britain and Spain, both then naval Powers, she resorted with signal good effect to privateering, not only for protection, but successful aggression. She obtained many privateers from Holland, and, by this force, gained decided advantages on the ocean over her enemy. Whilst in that condition, France could hardly have been expected to originate or concur in a proposition to abolish privateering. The condition of many of the smaller States of the world is now, in relation to naval Powers, not much unlike that of France in the middle of the sixteenth century. At a later period, during the reign of Louis XIV, several expeditions were fitted out by him, composed wholly of privateers, which were most effectively employed in prosecuting hostilities with naval Powers.

Those who may have at any time a control of the

ocean will be strongly tempted to regulate its use in a manner to subserve their own interests and ambitious projects. The ocean is the common property of all nations, and instead of yielding to a measure which will be likely to secure to a few—possibly to one—an ascendancy over it, each should pertinaciously retain all the means it possesses to defend the common heritage. A predominant Power upon the ocean is more menacing to the well-being of others than such a Power on land, and all are alike interested in resisting a measure calculated to facilitate the permanent establishment of such domination, whether to be wielded by one Power or shared among a few others.

The injuries likely to result from surrendering the dominion of the seas to one or a few nations which have powerful navies arise mainly from the practice of subjecting private property on the ocean to seizure by belligerents. Justice and humanity demand that this practice should be abandoned, and that the rule in relation to such property on land should be extended to it when found upon the high seas.

The President, therefore, proposes to add to the first proposition in the Declaration of the Congress at Paris the following words:—"And that the private property of the subjects or citizens of a belligerent on the high seas shall be exempted from seizure by public armed vessels of the other belligerent, except it be contraband." Thus amended, the government of the United States will adopt it, together with the other three principles contained in that Declaration.

I am directed to communicate the approval of the President to the second, third, and fourth propositions, independently of the first, should the amendment be unacceptable. The amendment is com-

mended by so many powerful considerations, and the principle which calls for it has so long had the emphatic sanction of all enlightened nations in military operations on land, that the President is reluctant to believe it will meet with any serious opposition. Without the proposed modification of the first principle, he cannot convince himself that it would be wise or safe to change the existing law in regard to the right of privateering.

If the amendment should not be adopted, it will be proper for the United States to have some understanding in regard to the treatment of their privateers when they shall have occasion to visit the ports of those Powers which are, or may become, parties to the Declaration of the Congress at Paris. The United States will, upon the ground of right and comity, claim for them the same consideration to which they are entitled, and which was extended to them, under the Law of Nations, before the attempted modification of it by that Congress.

As connected with the subject herein discussed, it is not inappropriate to remark, that a due regard to the fair claims of neutrals would seem to require some modification, if not an abandonment, of the doctrine in relation to contraband trade. Nations which preserve the relations of peace should not be injuriously affected in their commercial intercourse by those which choose to involve themselves in war, provided the citizens of such peaceful nations do not compromise their character as neutrals by a direct interference with the military operations of the belligerents. The laws of siege and blockade, it is believed, afford all the remedies against neutrals that the parties to the war can justly claim. Those laws interdict all trade with the besieged or blockaded places. A further

interference with the ordinary pursuits of neutrals in nowise to blame for an existing state of hostilities is contrary to the obvious dictates of justice. If this view of the subject could be adopted, and practically observed by all civilized nations, the right of search, which has been the source of so much annoyance, and of so many injuries to neutral commerce, would be restricted to such cases only as justified a suspicion of an attempt to trade with places actually in a state of siege or blockade.

Humanity and justice demand that the calamities incident to war should be strictly limited to the belligerents themselves, and to those who voluntarily take part with them; but neutrals, abstaining in good faith from such complicity, ought to be left to pursue their ordinary trade with either belligerent, without restrictions in respect to the articles entering into it.

Though the United States do not propose to embarrass the other pending negotiations, relative to the rights of neutrals, by pressing this change in the law of contraband, they will be ready to give it their sanction whenever there is a prospect of its favourable reception by other maritime Powers.

The Undersigned, &c.

(Signed) W. L. Marcy.

CHAPTER XX.

THE NAVAL OUTLOOK FROM WHITEHALL AT THE CLOSE OF THE CENTURY.

The British Navy Estimates which are debated in the summer represent the policy of the Admiralty and the various demands arising from that policy when the estimates were framed some six months earlier.

Just as this work draws to a close there is an opportunity to give a statement of this policy in the words of the Secretary to the Admiralty in the House of Commons. He said, as reported in the London *Times* 6th July, 1901:

The curiosity of the House is legitimately occupied with the manner in which the large vote to be taken in this and future years for new construction is to be expended. I may come at once to the description of the new ships which it is the intention of the Admiralty to lay down in the new programme. As to the battleships, there has been for a long time in this House a certain amount of controversy with regard to the character of the battleships which were being built in this country. There were some who felt that, in view of the progress which has been made by other nations in the matter of distribution of armour, there were changes which it was desirable should be made in the direction of giving larger offensive and larger defensive power to our battleships.

NEW BATTLESHIPS.

Once more the Admiralty intend to take a step in advance, and to produce a ship which will be superior to any battleship we have yet produced. The new battleships are to be vessels of approximately 16,500 tons displacement. They are to have a length 20 feet greater than the "Formidable class"; the indicated horse-power is 18,000; and it is hoped that they will realize on a trial of eight hours' continuous steaming 18½ knots speed. The protection, which in general character is similar to that of ships of the "London" class, will comprise an armour belt from the lower protected deck to a small height above the water-line of 9 inches, and thence from the main deck with a thickness of 8 inches; and this will be continued over the whole length between the barbettes and the heavy guns. A peculiar feature will be introduced in these ships which has never been introduced in recent battleships in the navy. The plan of placing the 6-inch guns in separate casemates will be abandoned, and the plan already adopted in a ship built in this country, but not for the government, will be followed. The ten 6-inch guns will be enclosed in a battery with 7-inch armour, and this battery will be divided by traverses to diminish the effect of any shell which may succeed in penetrating the 7-inch armour. The peculiarity of these ships which distinguishes them from their predecessors is that they will have a new feature in their armament. It is proposed to add to the four 12-inch guns now forming the normal armament of first-class battleships of the world four 9.2-inch guns. These are guns of very great power, which as yet have not been introduced in the second-ary armament of any first-class battleship. These

guns will be very well protected. They will be mounted on mountings similar to those placed in the "Cressy" class, and which, after careful tests, have been found to be the most trustworthy class of mounting. They will be protected by 6-inch to 7-inch armour, and two of them will have a forward fire and two of them an aft fire. The result will be that these ships will get a forward fire of two 12-inch guns, of two 9.2-inch, and two 6-inch guns, and the aft fire will be of the same formidable character. I think these ships will compare most favourably with any ships which, as far as we know, are being built for any European Powers, and we shall have great reason to be satisfied if they realize our expectations. Sometimes I hear it asked, "What's in a name?" There is, I think, a good deal in a name. It has been decided to give to these three great battleships names which, I think, will be appreciated. One of them will be called by the name of the Sovereign—the "King Edward." The other two ships will commemorate the great support rendered to His Majesty and to this country by two great branches of our kindred race. The other day there was celebrated the birth of the great Commonwealth of Australia, and only a day or two ago we celebrated the birthday of Canada; and it was felt not an inappropriate method of recognizing in our great naval service the military help rendered by those two branches of our community by naming the new ships *the Dominion and the Commonwealth.*

CRUISERS AND DESTROYERS.

The next item of construction is the cruisers. It is proposed to lay down six armoured cruisers. The

six cruisers will be in all material respects except one identical with the ships of the "Monmouth" class. These are vessels of 8,900 tons, 22,000 indicated horse-power, and 23-knot speed. The one difference will be the introduction of heavier armament. The ships of the "Monmouth" class will carry forward and aft two pairs of 6-inch guns. In the new ships we propose to place instead of two 6-inch guns a single 7.5-inch gun. There is a material increase in the power of the 7.5-inch gun as compared with the 6-inch gun. We believe that these cruisers will be fully able to take their part in competition with any cruisers we have reason to believe are likely to be brought against them. Lastly, with regard to the destroyers. The ten destroyers we propose to build are similar to the 30-knot destroyers of the latest type, but a wise departure is to be made in one respect. The 30-knot destroyer has a speed which, in my opinion and in the opinion of all those who make themselves acquainted with the life history of these boats, is very much a fancy speed. They have run this speed at the original trial at light draught, but when loaded to full draught these boats and others have been reduced by three or four knots from the ideal speed. It is proposed to make the new boats stronger in their general construction. We hope that they may be able to carry a larger supply of coal, and at the same time to ensure that they will run up to their full working load draught at the actual speed.

SCIENTIFIC EQUIPMENT.

The new ships we propose to build will be equipped in all respects in the most perfect manner which knowledge or scientific possibilities suggest. They

will receive all those accessories of which we have heard a good deal lately. They will be provided with the latest and most effective guns, and the most improved ammunition. Their guns will be provided with the cordite charges and with the telescopic sights. They will be provided with electric hoists, and their torpedoes will receive the gyroscope. Cordite is a comparatively new propellant. The powder chambers in several of the guns were designed to take the old black powder charges, and consequently the chambers were much too large for the small cordite charge. Experiments were immediately made to adapt cordite to those guns, and as soon as the experiments were completed we began to supply cordite charges for those guns. Wisely, I think, we began with the ships at home. We had to choose between furnishing the ships at home with the new charges or withdrawing ships from the active list in order to make experiments upon them. We preferred the former alternative; but there will be no difficulty, as soon as we think it desirable to withdraw those ships, to make the necessary alterations on them also. There has been no delay in the supply of those charges, and any indictment against the Admiralty on that head must, I believe, fail. There has been a similar complaint in regard to projectiles. That complaint also is not, I think, well founded. We are supplying to every one of the new ships armour-piercing shells. An armour-piercing shell is rather an expensive and complicated creature. It costs 1s. a pound and it is exceedingly peculiar in its structural qualities. Still, we have been making these shells with the greatest possible promptitude. They have been made for the whole of the ships carrying 12-inch guns and some of the ships carrying 13.5-inch guns, and

they are being made for the remainder. But, as we have over 300 ships in commission, probably more battleships in commission than the whole navy of France, it will be realized that to carry out this costly manufacture at the speed which some members appear to think desirable is practically impossible. What could be done has been done, and never for one moment has the Admiralty stinted money to provide the ships with the most perfect appliances. The gyroscope, again, is an exceedingly complicated and beautiful appliance. It is based on the principle that a rapidly revolving object will tend to preserve the direction in which it originally started. Its manufacture is a long process, involving considerable skilled labour, but still it has been carried out with unremitting zeal and a great many vessels are supplied with them. There has been no relaxation in the effort to provide all torpedoes with this necessary and desirable accomplishment. We have already ordered a considerable number of those electric hoists which were first introduced in an imperfect form into the "Powerful," "Terrible," and "Centurion." They are being put in their perfect form into the new battle-ships and cruisers. We are ordering a large number of the new hoists and we hope to introduce them into many of the ships which are at present completing for sea and some of the ships already at sea. Here, again, there has been a new departure which has been made after proper inquiry, and the result will be to give to the navy a perfect appliance as soon as manufacturing possibilities allow us to secure them. Neither in respect of the new ships nor the old ships have we neglected to do what we could in the way of providing equipment.

NEW DOCKS AND FLEET AUXILIARIES.

The six new docks which we hope to have available for the large battleships and cruisers will ameliorate the situation; and when we have completed the breakwater at Valetta, in Malta, for which money will be asked, we shall have improved our powers of protecting and docking these new ships in the Mediterranean. We have been reproached for not including in our programme certain auxiliary ships. The honorable member might give us credit for good intentions in so far as these were illustrated by actual performances. We have been reproached for not having a hospital ship. We have now a hospital ship, and a well-equipped one, which has been added to the navy by the generosity of a private individual who has been able to a certain extent to administer funds provided by a great friendly nation. The "Maine" will now take her position in the Mediterranean, and it will be found of enormous value. We have provided in these votes for a large amount of equipment for hospital ships in the event of war; and, in the opinion of the Admiralty, the equipment of hospital ships is one of those things which may, without disadvantage, be postponed until the probability or even the certainty of war. It would not be to the advantage of the navy, and it would be to the disadvantage of reasonable economy, to equip more of these ships in time of peace than are needed for peace time. We have also taken in these Estimates money for a repairing ship. That ship is in an advanced state of completion. Provision will also be made in the repairing ship for carrying a limited quantity of ammunition; but naval opinion is not as unanimous upon the question of the desirability in

peace time of specializing ships for this purpose as appears to be supposed in some quarters. That is a matter on which I do not express an opinion. We have taken £80,000 for the purchase or construction of coaling vessels, and, in addition to this, we have no less than seven chartered colliers regularly running at home and abroad for the coaling of the Fleet. It is thought by some that it might be better to build our own colliers for the purpose. There are two opinions about that, and I am much inclined to believe that the view of the Admiralty is the correct one. We get the services of these chartered colliers for the whole time we require them and in the places where we require them. If an estimate were framed for the construction of a collier it might easily happen, as has happened with almost every other class of ship, that in a short time this ship would be superseded by some other vessel. We believe that it is probable, if the practice of chartering colliers is continued and generally recognized as one of the demands likely to be made on the mercantile marine, that owners will adjust their colliers to our requirements, and will, in their interest and ours, provide a class of vessels which would in every way be suitable for our requirements. Meanwhile we have issued advertisements for tenders for five small steam colliers and four steam launches for local coaling services, and we are fitting a certain number of coal barges with the Temperley transmitters which are so invaluable in getting coal on board ships not lying alongside a wharf. I come to another point. Experiments were made during the last manœuvres as to what were the requirements of a distilling ship, and those experiments proved that the distilling ship we used for the purpose of the manœuvres was most unsuitable. The

experience then gained has been utilized for the preparation of a new distilling ship which is about to be added to the strength of the navy and which we believe to be much better. It has been said that we have no method of supplying fresh water to the ships. That is a mistake. In addition there is a powerful distilling apparatus at every station where it is not possible to obtain a proper supply of fresh water. The ship of which I have spoken is a valuable addition to the distilling plant we already have. It is a mistake to suppose that we have been so blind to the requirements of a modern navy as not to supply distilling plants for the purposes of the Fleet.

One great invention which has been made recently is that of wireless telegraphy. We have provided the Marconi apparatus for a large number of ships, but not for all. We have issued orders that every flagship, first-class cruiser, and second-class cruiser as she comes to be repaired shall be fitted with Marconi's wireless telegraph installation. We have been purchasing the whole of the component parts for those installations. They will be put in as those ships come in for repairs, whenever the ships do not already possess them.

CHAPTER XXI.

THE OPEN GATES.

The new century opens with a gathering of Naval Architects and Marine Engineers in the City of Glasgow in connection with the International Exhibition of 1901.

Glasgow University provided the workshop in which James Watt brought his mechanical instincts to the solution of the great problems in the development of the power of steam. At the foot of Gilmore Hill, on which the University stands, the exhibition buildings are grouped on either side of the banks of the Kelvin. There in the Marine Engineering and Shipbuilding Section are the exhibits of the great Clyde firms which have created the bulk of the modern mercantile shipping of the world.

There are the exhibits of Clydebank; Denny of Dumbarton; Stephen of Linthouse; the Fairfield works; Inglis of Pointhouse; the London and Glasgow Co.; the old Napiers' firm, now Beardmore; the Greenock firms and a crowd of others working on the shores of the Clyde. With these are joined the models of ships built by other British firms of high repute. There is the "Asahi" for Japan; the "Sutlej" and "Bacchante," 21 knot armoured cruisers; the "Leviathan," 23 knot armoured cruiser, 500 feet long and of 30,000 horse-power; the great cruisers "Cressy" and "Aboukir" of 12,000 tons; the 23 knot

armoured cruiser "Monmouth" and a large number of other vessels building for H. M. Government. Here also are the models of the Clyde-built ships for the Atlantic lines, for the Cape of Good Hope lines, for the Australian lines and for the Orient and other companies. Here are models of the "City of Paris" and "City of New York," built at Clydebank and employed with signal success as armed cruisers during the war between the United States and Spain. Here are the "Campania" and "Lucania," built at Fairfield and prepared to receive armaments as cruisers under the British flag. Clydebank exhibits the "Moskva," 20 knot cruiser for the Russian volunteer fleet. She is shown with her guns mounted.

So the new century opens with the recognition of the value of the well built merchant-ship for armed service in war and there is no more important and significant fact in the exhibition.

Those who would proportion the expenditure on armed shipping to the merchant shipping under the flag requiring to be protected should first remove subsidised cruisers from the helpless list and then add them to the armed shipping, assigning to them, in proportion to their tonnage, at least half the value assigned to armed cruisers.

The session of the Naval Architects opened appropriately enough with a paper by Lord Brassey on Mercantile Auxiliaries. Lord Brassey drew attention to the admitted value of these auxiliaries and showed that no proper appreciation had yet been shown in Parliamentary votes of the facts of the case. The amount asked for the navy in the Naval Estimates for the current year is £32,000,000 and the amount payable to the owners of our reserved merchant cruisers out of this amount is only £63,000.

The total value of our foreign trade is greater than that of France, Germany and Russia all taken together. It might surely be said that in order to secure the needed services of the mail ships in war for ourselves and prevent them falling into hostile hands the owners should be at least as much encouraged as those of these other countries. But what are the facts? The estimated amount of Postal subsidies paid by France, Germany and Russia is estimated at nearly 2½ millions sterling, while the Postal subsidy of Great Britain is only £637,000.

So it comes about that while in the last eight years we have added only one ocean going 18 knot ship to our Mercantile Marine Germany has built four during the last four years.

Lord Brassey said: "If the requirements were carefully considered in the original design, it would be possible to give as much, or nearly as much protection to the mercantile auxiliary as to the regularly built cruiser. Mr. Peskett, of the Cunard Company, has recently offered some practical suggestions on this subject in a lecture delivered at Liverpool. Mr. Peskett is a strong advocate for subsidies to mercantile auxiliaries, conditional upon the adaptation of the ships to the requirement of naval warfare. I may quote from a précis of his lecture:—'Merchant ships of the "Campania" or "Saxonia" class could actually be built lighter than they are under the present system, if they were built with one very strong deck, such as a protective deck with sloping sides, or with a deck of cellular form. The disposition of material in some of our large steamers is not perhaps in strict accordance with the best designs our naval architects could produce, but is entirely due to the requirements of owners, and the various registration societies.

I should say that a cruiser's hull, with protective deck, is lighter in proportion to her displacement than that of many of our first-class passenger steamers.

"'*Taking into consideration the fact that our supremacy depends on the efficiency of our Naval and Mercantile Marine, a committee of Admiralty officials, shipowners, and shipbuilders should be formed to discuss the best method of constructing a combined Naval and Mercantile Marine*, and to consider whether ships could be built as merchant cruisers, with protective decks, ram stems, machinery, and steering gear below the water-line, and still be able to carry enough passengers and mails, which with a reasonable subsidy would make the ships remunerative to owners.'

"These ships would have to be permanently mounted with light guns, racer plates for heavier armaments being built in the ships during construction, the heavier guns and mountings being kept at ports of call, and made to suit the various ships of any particular fleet.

"It has always been recognized that mercantile auxiliaries cannot be effective unless specially designed for conversion into cruisers. In the discussion at the Institute of Naval Architects on Mr. Barnaby's paper already referred to, Sir Edward Reed proposed that shipowners about to build large and swift merchant vessels should be invited to submit their plans to the Admiralty. The cost of any alterations which they might be willing to make in order to adopt these vessels for the emergency of war service should be met by a grant from the government.

"It is the main object of the present paper to urge the adoption of valuable and practical recommenda-

tions, which have been too long neglected. It is the fixed resolve of the people, and, perhaps the first duty of British statesmen, to keep the Empire secure from attack, and to give protection to the commerce on which our existence depends. In pursuance of this policy we have more than doubled the expenditure under Navy Estimates, and still we seem to fall short of the full requirements for the naval defence of the Empire. It would be impossible to fix a limit to the number of cruisers required for the protection of a commerce which extends over every sea. The construction of cruisers has absorbed in recent years a large proportion of the shipbuilding votes. But when the cost of the first-class types falls little short of that of the battleship, the numbers we can build are all too few for the work they might be required to do. We cannot cut down the expenditure on battleships.

"If, therefore, our regular built cruisers are fewer than we could wish, we must look to our own Mercantile Marine, and, out of the abundant materials we there find ready to our hands, we may organise a supplemental fleet of armed cruisers such as no other State can furnish. The Admiralty should utilise these resources by liberal subsidies. The standard of requirements should be high. The speed should not be less than that of the "Deutschland"—let us say, 22 knots at sea. Mercantile auxiliaries should be protected by a deck or belt of Harveyised armour—the necessary armaments should be in readiness. Calculations of cost can hardly be attempted in a paper in which nothing more is attempted beyond suggesting a policy. This, at least, is certain, that the cost of the adaptations and protective arrangements necessary in a mercantile auxiliary will be

small in comparison with the first cost of a regularly built vessel of war. For a first-class cruiser we may take the cost at three-quarters of a million. Allowing $3\frac{1}{2}$ per cent on the money invested, adding 6 per cent for depreciation, and 1 per cent for insurance, we have in round figures for the first cost an annual writing down charge of £70,000 a year.

"In addition, there is the cost of maintenance, which, whether in commission or in reserve, will certainly be considerable. Allowing for the protective arrangements of the mercantile auxiliary the liberal sum of £50,000, and a writing down charge on this amount of 10 per cent, and taking 10s. per ton displacement for the annual retainer, we have, for a mercantile cruiser of 10,000 tons, an annual charge of £10,000. We must further take into view the economy resulting from the maintenance of the mercantile auxiliary by the shipowners, as against the maintenance of the man-of-war in our Royal yards. In conclusion, I claim that it has been clearly shown that we can have many auxiliaries for the cost of one cruiser; and these auxiliaries may have effective protection. If not equal to the ship of war as combatants, they will be superior in coal endurance and probably in speed for long distances. They would be the scouts of our fighting squadrons. They would protect our commerce from interruption by the auxiliary vessels of a hostile Power.

"While the building of cruisers for the navy should be continued, the resources we possess in the marine, which our maritime enterprise has created in extent practically without limit, should not be neglected. Here, in Glasgow, I look for powerful support to a policy not now presented for the first time to the consideration of the Institute of Naval Architects. It has been advocated for many years by your ablest

men, it is being steadily pursued, to their signal advantage, by every naval administration: we are lagging behind, how seriously, has been shown by the figures which I have quoted. If the expenditure on auxiliary cruisers were raised from £60,000 to £600,000 a year, in a few years we should be enabled to provide no ineffective protection for our vast trade."

After discussion it was proposed by Admiral Sir J. Dalymple Hay, the oldest Vice-President of the Institution, seconded by Mr. Thornycroft, its most distinguished officer and member, and carried unanimously that "taking into consideration the fact that our supremacy* depends on the efficiency of our Naval and Mercantile Marine, a Committee of Admiralty Officials, Shipowners, and Shipbuilders should be formed to discuss the best method of constructing a combined Naval and Mercantile Marine." Steps will be taken by the Council of the Institution to endeavour to give effect to this resolution.**

Here then lies one ground of hope for the new Century: hope that as the maritime interests of Great Britain increase the defensive power of her shipping may increase. In speaking of Great Britain's interests it is clear that all human interests run on the same lines. It is to every one's advantage that where oversea commerce is there should be a corresponding defensive power, so that those with most to lose by war and therefore with the strongest incentives to peace may have corresponding power to ensure it.

These ships can never have the warlike efficiency of the regularly built men of war, but they have a proportionate efficiency which can be fairly estimated

*This word is not used in any sense different from what would be expressed by "National Security."

** Committee subsequently appointed by Lord Selborne.

and with proper guidance and subsidies the standard of efficiency will continually rise. The regular ships of war would then have clearly defined centres and circles of influence and the nation would know how to measure the necessity for the expenditures upon naval armaments.

Through the open gates of the Century at Glasgow this is one of the fair visions which we see.

Another closely related to it is the new rotary Marine Engine of the passenger vessel now on its trials from Messrs. Denny's yard. This vessel, the "King Edward," is to carry 2,000 passengers. The number of revolutions of the engines and propellers will be 1,000 per minute. There are difficulties to be overcome in this type of engine in getting economy at cruising speeds, and these affect mainly ships of war. Liners need not suffer from this limitation. And supposing the liners to be fitted with such engines their one note of inferiority as compared with regularly built ships of war will disappear.

The author has been concerned in building, with the full approbation of the navy, large cruisers having no more defensive power than the Atlantic liners have, excepting that the engines of the state cruisers were kept below the water-line while those of the liners stand high above water. The new engines go easily under the water level and, what is more, they will go under a protecting deck. Supposing these engines to be successful it will be the strict duty of governments to take up and subsidise every fast liner, so built, which the owners may be willing to charter on a standing contract and to arrange for an armament.

In this exhibition there is a model of a Cross Channel steamer to be propelled by Parson's compound

turbine or rotary engines working with 20,000 horse-power. This vessel is to be 275 feet long, 32 feet broad and 13 feet deep. The steam pressure is to be 250 lbs. per sq. in. and the estimated speed is 30 knots. The significance of this type of engine is so great in the problem of the development of the mercantile auxiliaries that it is to be hoped it may meet with unqualified success. The problem is as interesting to other powers as to ourselves. It is the one road to efficiency and economy combined, in the naval administration of maritime powers.

The "King Edward" was under trial on the Clyde during the visit of the Institution of Naval Architects at Glasgow and the report made of the result in the Scotch papers is as follows:

"The official trials of the turbine steamer 'King Edward,' which Messrs. Denny & Brothers, Dumbarton, have built for a Glasgow syndicate, were run on the Firth of Clyde yesterday. Hitherto the turbine has been applied only to torpedo-boat destroyers, but Mr. Parsons and his colleagues have always been sanguine of its success in propelling vessels of all kinds where a high rate of speed is necessary or desirable. They believe it is suitable for pleasure steamers, passenger and cross-channel steamers, liners (including Atlantic liners of the largest size), cruisers of all sizes, protected cruisers, and even battleships. The only conditions they stipulate for are that the vessel shall have a moderately high speed and be fairly large. For slow vessels and vessels of small size they do not, in the meantime, recommend the turbine. The pioneer vessel, the "Turbinia," built in 1894, proved the practical nature of Mr. Parson's theories, and the two torpedo-boat destroyers "Viper" and "Cobra" proved thoroughly that very high speed

can be united to economy in coal consumption. The "Viper" ran at 36 knots. At 31 knots, the guaranteed speed, the consumption was 2.38 lbs. per I. H. P., a fraction less than that required by the guarantee. After these "experiments," it remained for the promoters of the turbine method of propulsion to find a company enterprising enough to adapt the idea to a passenger steamer, and test the machinery in everyday work alongside other vessels with ordinary engines.

"The 'King Edward,' which was launched on the 16th of May, 1901, is a vessel 250 feet in length between perpendiculars, 30 feet in moulded breadth, and 17 feet 9 inches in depth moulded to promenade deck. The machinery consists of three separate turbines driving three screw shafts. The high-pressure turbine is placed on the centre shaft, which carries one propeller, and the two low-pressure turbines each drive one of the outer shafts, each shaft in this case carrying two propellers. Inside the exhaust ends of each of the latter are placed the two astern turbines, which operate by reversing the direction of rotation of the low-pressure motors and outside shafts. In ordinary ahead going the steam from the boilers is admitted to the high-pressure turbine, and after expanding about five-fold, it passes to the low pressure turbines, is again expanded in them about another 25-fold, and then passes to the condensers. At 20 knots the speed of revolution of the centre shaft is 700, and of the two outer shafts 1,000 per minute. When coming alongside a jetty, or manœuvring in or out of harbour, the outer shafts only are used, and the steam is admitted by suitable valves directly into the low-pressure motors, or into the reversing motors for going ahead or astern, on each side of the vessel.

The high-pressure turbine, under these circumstances, revolves idly, its steam admission valve being closed, and its connection with the low-pressure turbines being also closed by non-return valves. The main air-pumps are compound and worked by worm-gearing from the main engines in the usual way. There are also small auxiliary air-pumps worked from the circulating engines for draining the condensers before starting. The other auxiliary machinery is similar to that in vessels with reciprocating engines, and includes a feed-heater fed from the exhaust steam of the auxiliaries, and also when necessary by steam drawn from an intermediate point in the expansion of the main turbines.

"The boiler, which is a large double-ended one of the Scotch pattern, having a funnel at each end, is supplied by Messrs. Denny & Co., and the turbines, of which there are three, by the Parsons Marine Steam Turbine Co., of Wallsend on Tyne. The vessel has been built under the special supervision of the Board of Trade, and has a certificate for carrying over 2,000 passengers. She is intended for the Fairlie to Campbeltown service, and the estimated speed was 20 knots. This speed was obtained several times in preliminary trials, notably on Wednesday of this week, when the vessel ran at 20.483 knots on the measured mile at Skelmorlie, but it remained for yesterday to demonstrate publicly the capabilities of the new vessel, and at the same time practically begin running on the service for which she was built."

The "King Edward," which did the run back from Campbeltown to Prince's Pier at a speed of 20 knots, begins on Monday regular sailings from Fairlie to Campbeltown in connection with the Glasgow and South Western Railway. *Engineering* of 5th July,

1901, gives the following particulars of the engines:

"The propelling machinery consists of three Parsons' steam turbines working compound. These are placed side by side. In ordinary working, and when going ahead, steam is admitted from the boilers to the high-pressure turbine, where it is expanded fivefold. From thence it passes to the two low-pressure or wing turbines placed one on each side, where it is expanded 25-fold, and then passes to the condensers. The total ratio of expansion is therefore no less than 125-fold. Each turbine has its own shafting; and on each of the wing shafts there are two propellers, while the centre one carries only a single screw. When coming alongside a pier or manœuvring in crowded waters the wing motors alone are used, steam being admitted directly into them by suitable valves. The high-pressure turbine is then shut off, the steam-admission valve being closed, whilst connection between it and the low-pressure turbines is also shut off by an automatic arrangement. There are special turbines placed inside the exhaust ends of the low-pressure turbines for going astern with the wing screws. The whole of the manœuvring, excepting, of course, by the rudder, is effected by the manipulation of valves in a very simple manner. The feed-pumping engines are worked separately, as are the circulating pumps and fans for forced draught. The main air pumps are worked by means of worm gearing from the wing shafts; but there are auxiliary air pumps, actuated by the circulating-pump engines, for clearing the condensers of water when the main engines are not in operation. There is a feed heater which uses the exhaust steam, or steam taken from an intermediate point in the turbines if necessary. There is also a filter to clear the steam of grease. Other machinery

usual on vessels of this class is fitted. The boiler is of the usual return-tube type, being double-ended, and having four furnaces at each end. It is placed in a closed stokehold. The model has been subjected to a large number of trials in the Dumbarton experimental tank, and the result has been a very beautiful under-water shape. This keen bow and easy delivery are made possible by the lightness of the Parsons' turbine engines. The weight of the motors, condensers, with water in them, steam pipes, auxiliaries connected with the propelling machinery, shafting, propellers, &c., is 66 tons. This, we believe, is considered to be about half the weight per indicated horse-power developed of the average of the propelling machinery of paddle-boats of a similar type. There is also a gain in the hull construction due to the absence of paddle-boxes and sponsons.

"Another advantage resulting from the use of the turbine machinery is the additional passenger accommodation that can be provided. This is due to the lowness of the form, enabling the engines to be placed under the main deck.

"Still another advantage due to the adoption of this machinery is the noiselessness with which it runs. So far as the turbines themselves are concerned, it is not possible to tell whether they are running or not by placing one's hand on them. There is, however, a very slight vibration that can be felt right astern, and this is due to the propellers. Whether this can be eliminated or not remains to be seen, but certainly no vibration is set up by the main engines themselves."

In this forecast nothing has been said about other fuel as a substitute for coal. The use of oil in aid of coal seems likely to have a future before it. At pres-

ent it can only be said that it is in the matter of fuel that least has been done; and that there is great room for development.

The historian of Naval Development in the twentieth century will no doubt find how great things have been done by agencies which are now in their infancy. Among these may perhaps be the foundation in England of a National Physical Laboratory which has marked the closing year of the century. Moved by the Royal Society the Treasury was granted money for the establishment of such an institution. The Queen endowed it with the gift of one of the Royal Houses—Bushy House near Teddington on the Thames. Bushy House was for many years lent by the Sovereign of England to the exiled members of the Royal House of France. It is now being transformed, and in the course of a few months engineering shops and physical laboratories will be in full work. The navy will share in the good results of the researches thus endowed by the State, for nothing is without interest to the navy which affects metallurgy, electricity and chemistry, and these departments will be especially developed.

The laboratories will be open for investigations originated by any one who desires to institute them and they will be conducted confidentially for such private persons on the payment of the regular fees.

The director of the National Physical Laboratory is Professor Glarebrook, a well-known physicist.

APPENDIX I.

Report of committee appointed by the Board of Trade to enquire into the manning of British Merchant Ships, 1896:

"Since the final repeal of the navigation laws, which required that the master and three-fourths of the crew of every British ship should be British subjects, and reserved the coasting trade entirely to British ships and British seamen, the whole world has been open as a recruiting ground to British shipowners, who have not been hampered in their selection by any restriction as to colour, language, qualification, age or strength. Consequently the British born seaman has had to face competition with foreigners of all nationalities, not excepting negroes and Lascars, a competition more keen than any trade ashore has had to contend with, and all the more keen because employment on board ships is more accessible to foreigners than in any other description of British industry.

"We are informed that except with regard to certificates, which must be held by masters, officers, and engineers in certain cases, and which, moreover, may be obtained by men of any nationality, there is at present practically no bar to the employment of any person of any nationality in any capacity whatsoever on board any British ship.

"Having regard to the lower scales of wages and living amongst the foreigners with whom our seamen

have thus been brought into competition in British ships, it is not surprising that there has been a disposition on the part of British born seamen to escape from such competition and find employment ashore.

"It would appear that in 1891 the whole number of seamen employed in the foreign trade of the United Kingdom was 131,375 of whom 22,052 were foreigners, and 21,322 were Lascars, nearly 33 per cent in all being non-British. The number of A. B.'s in the foreign trade was 40,625, of whom 12,226 were foreigners, and 6,953 were Lascars, or over 47 per cent non-British.

"It should be remembered that the navigation laws, which limited the proportion of foreign seamen, secured the preponderance of British subjects in the crew of every British ship under that law as it formerly existed in this country, and under the present laws of nearly every foreign country, a vessel carrying (say) 24 hands should have at least 18 national seamen; but under the existing law of this country, British vessels may be, and often are, manned almost exclusively by foreigners.

"However undesirable it may be that British sailors should be thus ousted by foreigners from British ships, and however dangerous this change may prove to the State in time of war, the fact must be recognised that the existing unrestricted admission of foreigners and Lascars may eventually result in further diminishing outside of the Royal Navy, the number of British seamen. The qualified British seaman, enjoying no preference of employment over even the unqualified foreigner, and receiving no better pay, may abandon a competition in which the conditions are decidedly unfavourable to him.

"The shipowner may select his employes from all

nationalities, at any rates of wages, and may also (as the law now stands) at his discretion or caprice, either require or dispense with proofs of qualification. On the other hand, the British sailor having perhaps qualified himself for the rating of A. B. by four years' service before the mast, may present himself at a shipping office and sign articles—on no better terms as regards food, berthing, and pay—with Scandinavians, Germans, French, Italians, Greeks, Turks and Negroes, some of whom may possess no proof of qualification, and no adequate knowledge of the English language, but who are protected as regards employment in vessels of their own nationalities, wherever such vessels exist. It is the opinion of the committee that any deterioration of British seamen which may now exist is not owing to the decadence of our countrymen, nor to their dislike for the sea, but to the lack of sufficient attraction in the sea service as at present conducted to draw and hold the best class of British workmen, and in a great measure to an insufficient number of boys being trained, to supply the necessary waste in the number of A. B.'s.

"We feel constrained therefore to emphasise the fact that whatever grounds there may be for fearing foreign competition in the ownership of vessels as the result of manning legislation, we owe, as we have just seen, to the absence of legislation on the subject of manning a form of competition so aggravated as to threaten to drive the British able seaman and fireman out of our merchant ship.

"Amongst the remedies proposed by the shipowners' representatives is the establishment, *at the public expense*, of training ships for boys for the purpose of increasing the number of available British seamen,

the Royal Navy to have at all times the first claim upon the services of those so trained, who shall, however, be free to obtain employment in the Mercantile Marine or elsewhere when they are not required for service in the Royal Navy."

Mr. Joseph Hoult, one of the members of the Committee, adds: "Generally, British shipping is on the wane. Other countries are making rapid advances, and it behoves Parliament to take immediate steps for the protection of the shipping industries against the unfair competition of foreign shipping, and try to foster the industry which in times of peace is the most vital the country has, and in the event of war that on which the very existence of the country would depend."

APPENDIX II.

Note on Building before placing ships "in Ordinary."

A few years ago when the ribs, beams, and planking of a ship were built after an approved and time-honoured pattern, it was usual to estimate the progress which had been made in her construction by observing how many of her timbers were trimmed, how many beams were across, and how much of her planking had been worked. It had been ascertained by long observation what proportion the labour upon these successive stages usually bore to the total labour required to build the ship, and the estimated proportion at any given stage was expressed by a fraction of which the base was 8. When the ship was half built it was said that $\frac{4}{8}$ had been built. Curiously enough this mode of calculation did not proceed beyond the point when the ship was ready for launching. There might be a large amount of labour required to fit the ship for sea, but this was a varying and uncertain amount depending upon the nature of the service for which the ship was to be fitted, and upon alterations which might be made in rig, cabin accommodations and other matters. The progress of "building" as it was called, was considered entirely apart from the work of fitting-out, and the Returns made to Parliament were fairly accurate but of very little value.

APPENDIX III.

Losses of ships of the British Royal Navy in the early part of the nineteenth century, distinguishing between those captured or destroyed by the enemy and those otherwise lost.

The losses due to the ordinary perils of life at sea are so large as to emphasise the difference between life in sailing-ships and life in steam-ships. The losses of steam-ships in the Royal Navy during the last quarter of the nineteenth century by ordinary sea perils appear to number just six. His Majesty's ships very often take the ground and sometimes remain hard and fast aground for a time; but with steam power, sometimes their own and sometimes that of consorts they get off again. They usually take the ground under circumstances favourable for recovery. Sailing ships driven ashore by stress of weather nearly always become total wrecks. Familiarity with disaster in this form has dropped out of the sailor's life.

The list is abstracted from Vol. V of *The Royal Navy*, edited by Mr. W. Laird Clowes and others, and published by Messrs. S. Low Marston & Co. It is given here by their kind permission. The original list gives the names of officers in command of the ships at the dates of their loss and also gives the losses in the French and Spanish navies.

LIST OF H. M. SHIPS TAKEN, DESTROYED, BURNT, FOUNDERED, OR WRECKED DURING THE YEARS, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1803	Mar. 26 ..	"Déterminée"............	22	Wrecked near Jersey.
	May 31...	"Resistance"	36	Wrecked on Cape St. Vincent.
	July 2....	"Minerve"	38	Grounded and taken near Cherbourg.
	July 21...	"Seine".................	38	Wrecked off the Texel.
	....	"Surinam"	18	Detained by the Dutch at Curaçoa.
	Aug......	"Calypso"...............	16	Run down in the Atlantic.
	Aug......	"Redbridge," (sch.).......	12	Taken by French off Toulon.
	Nov. 16 ..	"Circe"..................	28	Wrecked on the Lemon and Ower.
	Nov. 16 ..	"Garland"...............	22	Wrecked off Cape François.
	Dec. 10...	"Shannon"	36	Wrecked and burnt near La Hougue.
	Dec.......	"Avenger"	14	Foundered off the Weser.
	Dec. 15...	"Suffisanté".............	16	Wrecked in Cork harbor.
	Dec. 31...	"Grappler," (g. v.)	12	Grounded and burnt by French at Chausey.
1804	Jan. 2....	"Créole"	38	Foundered in the Atlantic.
	Jan. 6....	"Raven".................	18	Wrecked near Mazari, Sicily.
	Jan.......	"York"..................	64	Supposed foundered in N. Sea. All lost.
	Feb.......	"Fearless"...............	12	Wrecked in Cawsand Bay.
	Feb.......	"Hussar"................	38	Wrecked on the Saintes, B. of Biscay.
	March 1..	"Weazel"................	14	Wrecked near Gibraltar.
	March 24.	"Wolverine"	14	Taken by French privateer Blonde, Atlantic.
	March 25.	"Magnificent"	74	Wrecked near the Pierres Noires, Brest.
	April 2...	"Apollo"................	36	Wrecked on coast of Portugal.
	May 8....	"Vencejo"...............	16	Taken by French gunboats, Quiberon Bay.

BRITISH LOSSES, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1804	July 15...	"Lily"................	16	Taken by priv. "Dame Ambert," 16, off Georgia.
	Sept. 3...	"De Ruyter," (storeship).	64	Wrecked at Antigna.
	Sept.....	"Drake"................	14	Wrecked off Nevis.
	Oct. 24...	"Conflict"...............	12	Wrecked off Newport, I. W.
	Nov. 12...	"Lord Eldon," (hired A.S.)	16	Taken by Spanish gunboats. Retaken later.
	Nov. 19...	"Romney"...............	50	Wrecked near the Texel.
	Nov. 24...	"Venerable"............	74	Wrecked off Roundham Head, Torbay.
	Nov.	"Hannibal," (hired A. S.).	16	Wrecked near Sandown Castle.
	Dec. 15...	"Gertrude," (hired sch.)..	16	Run down by the "Aigle," Channel.
	Dec. 18...	"Starling"...............	12	Wrecked near Calais.
	Dec. 20...	"Tartarus," bomb........	12	Wrecked on Margate sands.
	Dec.......	"Mignonne".............	18	Driven ashore in the W. Indies.
	Dec. 21...	"Severn,"...............	44	Wrecked in Grouville Bay, Jersey.
	Dec. 25...	"Mallard"...............	12	Grounded and taken near Calais.
1805	Jan. 7....	"Sheerness"............	44	Wrecked near Trincomalee.
	Jan. 21...	"Doris"................	36	Wrecked in Quiberon Bay.
	Jan. 29...	"Raven"...............	18	Wrecked in Cadiz Bay.
	Feb. 4....	"Arrow"................	30	Taken by the "Hortense" and "Incorruptible," Mediterranean.
	Feb. 17...	"Cleopatra"............	32	Taken by the "Ville de Milan," N. America.
	Feb.......	"Bouncer"..............	12	Wrecked off Dieppe.
	Mar. 1....	"Imogene"..............	18	Foundered in the Atlantic.
	(?) May...	"Hawk"................	18	Foundered in the Channel. All lost.
	(?).......	"Seagull"...............	18	Foundered, date unknown. All lost.

BRITISH LOSSES 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1805	(?)	"Mary," hired	16	Foundered, date unknown. All lost.
	May	"Fly"	16	Wrecked in the Gulf of Florida.
	May 12	"Cyane"	18	Taken by the "Hortense" and "Hermione." Retaken 5 Oct., 1805.
	July 12	"Orestes"	14	Wrecked off Dunquerque.
	July 16	"Plumper"	12	Taken by five gun-brigs off St. Malo.
	July 16	"Teazer"	12	Taken by five gun-brigs off St. Malo.
	July 17	"Ranger"	16	Taken and burnt by the Rochefort squadron.
	July 19	"Blanche"	36	Taken and burnt by a French squadron, West Indies.
	Aug.	"Pigmy," schooner	14	Wrecked in St. Aubin's Bay, Jersey.
	Aug.	"Althorpe," hired cutter.	16	Foundered in the channel.
	Sept. 26	"Calcutta,"	54	Taken by Allemand's squadron off Scilly.
	October	"Orquijo"	18	Foundered near Jamaica.
	Nov. 10	"Biter"	12	Wrecked near Calais.
	Nov. 18	"Woodlark"	12	Wrecked near St. Valery.
1806	Jan.	"Manly"	12	Seized by the Dutch in the Ems.
	Jan. 6	"Favorite"	18	Taken by a French squadron, Atlantic.
	Feb.	"Seaforth"	14	Capsized, W. Indies. All lost save two.
	April 12	"Brave"	74	Foundered off the Azores.
	Aug.	"Dover," prison ship (in ord.)	44	Accidentally burnt off Woolwich.
		"Heureux"	22	Foundered in the Atlantic. All lost.
	Sept. 5	"Wolf"	16	Wrecked among the Bahamas.

BRITISH LOSSES, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1806	....	"Serpent"	16	Foundered on the Jamaica station. All lost.
	....	"Martin"	16	Foundered in the Atlantic. All lost.
	Oct. 12...	"Constance"	22	Grounded and taken, near C. Fréhel.
	Oct. 27...	"Athénien"	64	Wrecked near Sicily, many lost.
	Nov. 4....	"Redbridge," schooner	12	Wrecked near Providence.
	Dec. 9....	"Adder"	12	Driven ashore and taken near Abreval.
	Dec. 17...	"Netley," schooner	14	Taken by two French cruisers, West Indies.
	Dec......	"Clinker"	12	Foundered off Le Hâvre. All lost.
1807	Jan. 4....	"Nautilus"	22	Wrecked on Cerigotto, Mediterranean.
	Jan. 22...	"Felix"	12	Wrecked near Santander. All lost save three.
	Jan. 23...	"Orpheus"	32	Wrecked on a coral reef, West Indies.
	....	"St. Lucia	14	Taken by the French, West Indies.
	(?) Feb. 2.	"Blenheim"	74	Foundered in Indian Ocean; all lost.
	(?) Feb. 2.	"Java"	32	Foundered in Indian Ocean; all lost.
	Feb. 14...	"Ajax"	74	Accidentally burnt, Mediterranean.
	Feb. 18...	"Inveterate"	12	Wrecked off St. Valery en Caux.
	Feb. 18...	"Griper"	12	Foundered off Ostend; all lost.
	Feb. 18...	"Speedwell"	14	Foundered off Dieppe.
	....	"Busy"	18	Foundered, Halifax Station; all lost.
	Feb.......	"Atalante"	16	Wrecked off Rochefort.
	March 2..	"Pigmy"	14	Wrecked off Rochefort.
	March 4..	"Blanche"	38	Wrecked off Ushant.
	March ...	"César"	16	Wrecked off the Gironde.
	March 31.	"Ferreter"	12	Taken by seven Dutch gunboats, River Ems.

BRITISH LOSSES, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1807	May 26...	"Dauntless"	18	Taken at the surrender of Dantzig.
	May 29...	"Jackal"	12	Wrecked near Calais.
	Sept. 10..	"Explosion"	12	Wrecked near Helgoland.
	....	"Moucheron"	16	Wrecked in the Mediterranean.
	Oct. 16...	"Pert"	14	Wrecked off Santa Margarita.
	Nov. 10...	"Leveret"	18	Wrecked on the Galloper.
	Nov. 11...	"William," (storeship)	12	Wrecked in the Gut of Canso.
	Nov. 17...	"Firefly"	12	Foundered off Curaçoa; nearly all lost.
	Dec. 5....	"Boreas"	22	Wrecked near Guernsey; many lost.
	Dec. 29...	"Anson"	44	Wrecked off Mount's Bay.
	....	"Elizabeth"	12	Foundered in the W. Indies; all lost.
1808	Jan. 12...	"Sparkler"	12	Wrecked on the Dutch coast.
	Jan. 19...	"Flora"	36	Wrecked and destroyed on Dutch coast.
	Jan. 31...	"Delight"	16	Wrecked and burnt on Calabrian coast.
	Jan. 31...	"Leda"	38	Wrecked at mouth of Milford Haven.
	March ...	"Hirondelle"	14	Wrecked near Tunis; nearly all lost.
	March 24.	"Muros"	20	Wrecked in Honda Bay, Cuba.
	March 25.	"Electra"	16	Wrecked on coast of Sicily.
	March 26.	"Milbrook"	12	Wrecked on the Burlings.
	April 22..	"Bermuda"	18	Wrecked on Memory Rock, Little Bermuda.
	May 18...	"Rapid"	12	Sunk by batteries in the Tagus.
	May 24...	"Astrœa"	32	Wrecked off Anegada, W. Indies.
	June 4....	"Tickler"	12	Taken by four Danish gunboats, Great Belt.
	June 9....	"Turbulent"	12	Taken by a Danish flotilla, Malmö Bay.

BRITISH LOSSES, 1803-15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1808	June 19...	"Seagull"	16	Taken by a Danish flotilla, off the Naze.
	July 10...	"Netley"	12	Wrecked on Leeward Islands Station.
	July 30...	"Meleager"	36	Wrecked on Barebush Key, Jamaica.
	Aug. 2....	"Tigress"	12	Taken by sixteen Danish gunboats, Great Belt.
	Aug. 4...	"Delphinen"	16	Wrecked on the Dutch coast.
	Sept. 15..	"Laurel"	22	Taken by the "Canonnière," 40, Indian Ocean.
	Sept. 29..	"Maria"	14	Taken by "Dépt. des Landes," 22, off Guadeloupe.
	Oct. 3....	"Carnation"	18	Taken by "Palinure," 16, off Martinique.
	Oct. 4....	"Greyhound"	32	Wrecked on coast of Luconia.
	Oct. 24...	"Volador"	16	Wrecked in Gulf of Coro, W. Indies.
	Dec. 4....	"Banterer"	22	Wrecked in the St. Lawrence.
	Dec. 6....	"Crescent"	36	Wrecked on the coast of Jutland.
	Dec. 10...	"Jupiter"	50	Wrecked in Vigo Bay.
	Dec. 23...	"Fama"	16	Wrecked in the Baltic.
	Dec. 26...	"Bustler"	12	Wrecked on coast of France.
1809	Jan. 9....	"Morne Fortunée"	12	Wrecked off Martinique.
	Jan. 11...	"Magnet"	18	Wrecked in the ice, Baltic.
	Jan. 22...	"Primrose"	18	Wrecked on the Manacle, near Falmouth.
	Feb. 28...	"Proserpine"	32	Taken by "Pénélope" and "Pauline" off Toulon.
	Mar......	"Harrier"	18	Supposed foundered, Indian Ocean.
	April 11..	"Mediator," t.s. a.s.f. ship	36	Expended in Basque Road.
	April 29..	"Alcmene"	32	Wrecked off Nantes.
	May 31...	"Unique"	12	Burnt at Basseterre, Guadeloupe.

BRITISH LOSSES, 1803-15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1809	June 20	"Agamemnon"	64	Wrecked in the River Plate.
	July 11	"Solebay"	32	Wrecked on the coast of Africa.
	Aug. 8	"Lark"	18	Foundered off San Domingo.
	Aug. 10	"Alaart"	16	Taken by a Dutch flotilla.
	Aug.	"Dominica"	14	Capsized off Tortola.
	Aug. 31	"Foxhound"	18	Foundered in the Atlantic. All lost.
	Sept. 2	"Minx"	12	Taken by six Danish gunboats.
	Nov. 2	"Victor"	18	Taken by the "Bellone," 40, B. of Bengal.
	Nov. 3	"Curieux"	16	Wrecked in the W. Indies.
	Nov.	"Glommen"	16	Wrecked in Carlisle Bay, Barbados.
	Dec. 7	"Harlequin"	16	Wrecked near Seaford.
	Dec. 13	"Junon"	38	Taken by the "Renommée" and "Clorinde."
	Dec. 14	"Defender"	12	Wrecked near Folkestone.
	....	"Contest"	12	Supposed foundered in the Atlantic.
	Dec.	"Pelter"	12	Lost in the Atlantic.
1810	May 24	"Flèche"	16	Wrecked off the mouth of the Elbe.
	May 24	"Racer," cutter	12	Wrecked on the coast of France.
	Aug. 24	"Néréide"	36	Taken by a French squadron, off Grand Port.
	Aug. 25	"Magicienne"	36	Destroyed, to avoid capture, off Grand Port.
	Aug. 25	"Sirius"	36	Destroyed to avoid capture, off Grand Port.
	Aug. 26	"Lively"	38	Wrecked near Malta.
	Aug. 28	"Iphigenia"	36	Taken by a French squadron near Grand Port.
	Nov. 9	"Conflict"	12	Foundered in the Bay of Biscay.
	....	"Mandarin"	12	Wrecked on Red Island, Strait of Singapore.

BRITISH LOSSES, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1810	Nov.	"Plumper"	12	Foundered in the St. Lawrence.
	Dec. 18	"Pallas"	32	Wrecked off the Firth of Forth.
	Dec. 18	"Nymphe"	36	Wrecked off the Firth of Forth.
	Dec. 22	"Minotaur"	74	Wrecked off the Haak Sand, Texel.
	Dec. 25	"Monkey"	12	Wrecked near Belle Isle.
1811	Jan. 19	"Satellite"	16	Foundered in the Channel.
	Feb. 13	"Pandora"	18	Wrecked in the Kattegat.
	Feb. 16	"Amethyst"	36	Wrecked in Plymouth Sound.
	March 12	"Challenger"	16	Taken by a French frigate, etc., off Ile Batz.
	May 2	"Dover"	38	Wrecked in Madras Road.
	May 2	"Chichester," storeship	32	Wrecked in Madras Road.
	May 26	"Alacrity"	18	Taken by the "Abeille," 20, off Corsica.
	June 28	"Firm"	12	Wrecked on the French coast.
	June 29	"Safeguard"	12	Taken by the Danes in the Baltic.
	....	"Staunch"	14	Wrecked off Madagascar; all lost.
	Aug. 18	"Tartar"	32	Wrecked in the Baltic.
	Sept. 2	"Manly"	12	Taken by three Danish brigs.
	Oct. 14	"Pomone"	38	Wrecked on the Needles.
	Dec. 4	"Saldanha"	36	Wrecked off Lough Swilly; nearly all lost.
	....	"Bloodhound"	12	Wrecked near Trevose Head.
	Dec. 24	"Fancy"	12	Foundered in the Baltic; all lost.
	Dec. 24	"St. George"	98	Wrecked on the coast of Jutland; nearly all lost.
	Dec. 24	"Defence"	74	Wrecked on the coast of Jutland; nearly all lost.

BRITISH LOSSES, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1811	Dec. 25	"Hero"	74	Wrecked on the Haak Sand; all lost.
	Dec. 25	"Grasshopper"	18	Taken in Nieuwe Diep, Texel.
1812	Jan. 28	"Manilla"	36	Wrecked on the Haak Sand, Texel.
	Jan. 31	"Laurel"	38	Wrecked on the Govivas Rock, Teigneux Passage.
	Feb. 29	"Fly"	16	Wrecked off Anholt.
	May 3	"Skylark"	16	Grounded, and was destroyed near Boulogne.
	May 3	"Apelles"	14	Grounded, and was taken, near Boulogne. Retaken, 4 March, 1812.
	July 8	"Exertion"	12	Grounded, and was destroyed in the Elbe.
	July 11	"Encounter"	12	Wrecked off San Lucar, Spain.
	Aug. 3	"Emulous"	18	Wrecked on Sable Island.
	Aug. 13	"Alert"	16	Taken by the U. S. S. "Essex," 32.
	Aug. 19	"Attack"	12	Taken by fourteen Danish gunboats, off Anholt.
	Aug. 19	"Guerrière	38	Taken by the U. S. S. "Constitution," 44.
	Sept. 8	"Laura"	12	Taken by the French priv. "Diligente."
	Sept. 28	"Barbados"	28	Wrecked on Sable Island.
	Oct. 8	"Avenger"	16	Wrecked off St. Johns', Newfoundland.
	....	"Magnet"	16	Supposed foundered in the Atlantic; all lost.
	Oct. 10	"Sentinel"	12	Wrecked off Rügen.
	Oct. 18	"Frolic"	18	Taken by U. S. S. "Wasp," 20.
	Oct. 25	"Macedonian"	38	Taken by U. S. S. "United States," 44.
	Nov. 24	"Bellette"	18	Wrecked in the Kattegat; nearly all lost.
	Nov. 27	"Southampton"	32	Wrecked off Conception Island, Bahamas.

BRITISH LOSSES, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1812	Dec. 5	"Plumper"	12	Wrecked in the Bay of Fundy.
	Dec. 8	"Fearless"	12	Wrecked off the coast of Spain.
	Dec. 29	"Java"	38	Taken by U. S. S. "Constitution," 44.
1813	Jan. 7	"Ferret"	18	Wrecked near Leith.
	Jan. 27	"Daring"	12	Destroyed to prevent capture by "Rubis."
	Jan. 24	"Peacock"	18	Taken by U. S. S. "Hornet." Sank.
	Jan. 25	"Linnet"	14	Taken by the "Gloire," 40, off Madeira.
	March 22	"Captain"	74	Accidentally burnt in Hamoaze.
	June 16	"Persian"	18	Wrecked on Silver Keys, West Indies.
	July 2	"Dædalus"	38	Wrecked off Ceylon.
	Aug. 5	"Dominica"	14	Taken by U. S. privateer, "Decatur."
	Aug. 22	"Colibri"	18	Wrecked at Port Royal, Jamaica.
	Sept. 5	"Boxer"	12	Taken by U. S. S. "Enterprise," 16.
	Sept. 21	"Goshawk"	16	Wrecked in the Mediterranean.
	Sept. 27	"Bold"	12	Wrecked on Prince Edward's Island.
	Oct. 22	"Laurestinus"	22	Wrecked on the Silver Keys.
	Nov. 5	"Tweed"	18	Wrecked in Shoal Bay, Newfoundland.
	Nov. 6	"Woolwich," en flûte	40	Wrecked off Barbuda.
	Nov. 10	"Atalante"	18	Wrecked off Halifax.
1814	Feb. 14	"Pictou"	16	Taken by the U. S. S. "Constitution."
	Feb. 28	"Anacreon"	18	Foundered in the channel.
	....	"Vautour"	16	Supposed foundered. All lost.
	April 29	"Epervier"	18	Taken by U. S. S. "Peacock."
	May 19	"Halcyon"	18	Wrecked on a reef, West Indies.

BRITISH LOSSES, 1803–15.

Year.	Date.	H. M. Ship.	Guns.	Remarks.
1814	June 28..	"Reindeer"	18	Taken by U. S. S. "Wasp," channel.
	June 28..	"Leopard," troopship	50	Wrecked off Anticosti.
	Aug......	"Peacock"	18	Foundered off South Carolina. All lost.
	Sept. 1...	"Avon"	18	Sank after action with U. S. S. "Wasp."
	Sept. 15..	"Hermes"	20	Destroyed in attacking batteries at Mobile.
	Sept. 30..	"Crane"	18	Foundered in the West Indies.
	Oct. 10...	"Racer"	14	Wrecked in the Gulf of Florida.
	Nov. 24 ..	"Fantôme"	18	Wrecked on the Halifax Station.
1815	Jan. 17...	"Sylph"	18	Wrecked on Southampton Bar, North America.
	Feb. 26...	"Statira"	38	Wrecked off Cuba.
	Feb. 26...	"St. Lawrence"	12	Taken by U. S. privateer, "Chasseur," 24.
	March 20.	"Levant"	22	Taken by U. S. S. "Constitution." Retaken.
	March 20.	"Cyane"	20	Taken by U. S. S. "Constitution." Retaken.
	March 23.	"Penguin"	18	Taken by U. S. S. "Hornet" off Tristan d'Acunha.
	May 1....	"Penelope," troopship	36	Wrecked off Newfoundland.
	Aug. 15..	"Dominica"	14	Wrecked off Bermuda.
	(?)	"Cygnet"	16	Wrecked off the R. Courantyn.

APPENDIX IV.

Steadiness at Sea.

When armour was first introduced it was feared that armoured sea-going ships would behave badly; that they would wallow in the seas, and otherwise misbehave themselves. And the earlier ships did this. There is perhaps no greater triumph to record in relation to big ships than the arrangements by which the heavy sea-going ships, loaded with armour, are made to foot it over the seas as gently and gracefully as the slim Atlantic Liner.

This latter type of ship can behave on occasion very badly. But the horrors of sea sickness are best appreciated, so far as steam ships are concerned in a cross channel steamer.

In order to overcome this disagreeable feature of travelling life Mr. J. I. Thornycroft of Chiswick fitted up a yacht with a steadying apparatus. The yacht had a displacement or total weight of 230 tons and the controlling weight by which the ship was to be balanced was 8 tons. When this weight was pushed over by the apparatus to be described the vessel was made to incline 2°, i. e., the vessel when upright and at rest, could be made to incline 2° to starboard or to port, according to the side to which the controllable ballast was moved. If it were proposed to balance a ship among average Atlantic waves, which are perhaps 180 feet long, the maximum slope

of the waves would have to be assumed to be about seven degrees. If such a movable weight is provided that when out to the fullest extent of its travel on one side of the centre line of the ship it will incline her 7° in still water then this weight will suffice to keep the vessel quite steady among any waves having a slope not exceeding seven degrees.

But the ameliorating effect of a very much smaller amount of weight than this is very marked. Suppose, for instance, the weight employed is only sufficient to incline the vessel 3½ degrees in still water, the roll due to a wave slope of 7° would be reduced by one half. The heavy rolling seen occasionally in Atlantic steamers, which is not caused by waves of a very steep slope, but by a succession of waves keeping time with her swing is something which can be stopped with a very much smaller weight than would be necessary to heel her over to the large angle sometimes attained; in fact a very moderate weight would suffice to prevent it.

A passenger on board the yacht so fitted describes the result very vividly. The passenger was the Director of Naval Construction in the British Navy. He said, "By the courtesy of Mr. Thornycroft, I have had an opportunity of taking a trip to sea in the 'Cecile,' to look for bad weather and observe the working of this apparatus. I feel bound to say a word or two on what I then saw. It is quite unnecessary for me to say anything in order to emphasise the impression that Mr. Thornycroft's own description must have created of the wonderful ingenuity and practical success of this apparatus, which was tried in this yacht under very adverse conditions. The yacht was very stiff, with a metacentric height of about 4½ ft. and a very short period. Both of these cir-

cumstances tell against the gear. Yet by my own observation I can certify to the fact that the movement of a relatively small weight did destroy half the rolling. The vessel, being put beam on to the sea, was first tested with the gear out of action, the weight being fixed, and then with the weight moving. The average range of oscillation in the one case was only half what it was in the other. Mr. Thornycroft says perhaps less than the truth in remarking the last half of a big angle is usually the most distressing to those who feel angular motion. Moreover, he has only dealt lightly with one part of his apparatus, where he probably deserves the greatest credit. We all know that Mr. Thornycroft, in speaking of his own work, is always modest, and in this particular department I think he has excelled himself. It is very easy to speak of controlling the gear of a hydraulic ram by the movement of a small pendulum, which pendulum follows the rolling of a very quick-moving yacht. But it is quite another thing to secure that control. In my judgment, whatever may be the outcome of this electrical arrangement for the special purpose which Mr. Thornycroft has here in view, the use of similar arrangements will not be limited to this particular class of apparatus. I believe Mr. Thornycroft has secured his rights for other possible uses of the apparatus, and I am confident that the beautiful, almost automatic, and, I may say, intelligent movements one sees in this gear will be capable of very wide application. But the peculiar thing about this apparatus is that when watching its working, or, if you prefer it, sitting at table and eating, you know at once what is going to happen from the working of the gear. A long series of fairly uniform waves may be met; then the weight moves regularly, and you

hear it moving to and fro below the cabin floor, and gain, it may be, great comfort from the knowledge. Then there comes a 'smooth' or an exceptional wave. When the 'smooth' comes on, the apparatus seems to say, 'Am I to start?' It is quite ready to start, and it seems as if it would start, but it says, 'No; it is a false alarm,' and stands still. That is an absolutely correct description. It is no exaggeration. Mr. Thornycroft will bear me out, and also Mr. Tower, who was on board with me. Whatever the controlling gear was called upon to do by the wave phenomena outside the vessel, it did neither more nor less. As to the possible application of this beautiful arrangement, which is based, as Mr. Thornycroft tells us, strictly on the investigations of the late Mr. Froude, I do not pretend to speak. I have my own thoughts on that matter. One can say this, however, that the idea of moving a weight to check rolling is not a new one. Mr. Winans in his cigar ships, proposed to have moving weights. I have heard that such weights were actually fitted, but there was no efficient controlling gear; and a moving weight which does not do what is expected of it may, of course, be a danger instead of an advantage."

Mr. Thornycroft describes the apparatus as follows:

"The motion of a ship at sea, generally known by the term 'rolling,' is not only productive of much discomfort, but in many cases is a source of considerable danger: this motion of a vessel I have been endeavouring to overcome. It is probable that automatic steadying gear was made at a very early period; for when men first added sails to their canoes as a means of propulsion, these sails also gave steadiness, although not originally intended for that purpose.

The extended use of steam is depriving fast passenger vessels of this ancient steadying gear, which is still one of the best, and consequently causing increased rolling. For comfort at sea we require in our ships some device that will afford the resistance to rolling which the sails gave. The need is an increasing one, because it is now usual for steamers to keep their course in bad weather; although with greater speed the apparent period of the waves may be so much lengthened as to cause coincidence with the natural period of rolling of even the largest vessels, and Lord Kelvin has measured angles of roll, in crossing the Atlantic, of 40° each way from the vertical, giving a total angular motion in one roll of 80°. Mr. Tower's success with his steady platform on board ship, induced me to believe that it was perhaps possible to steady the whole ship as far as rolling was concerned.

"The effect of moving the centre of gravity of any vessel can be estimated with certainty, even though the ship be exposed at the same time to any particular system of waves, and by this means a vessel may be effectually steadied. The modern theory of the conditions which govern rolling is due to the late Mr. William Froude. It is founded on the fact that the free surface of a liquid is always, in a sense, level; but when it is undulating it has alternate angular motion, which tends to roll a vessel by means of her own stability.

"The term 'stability' correctly describes the property of returning to a position of equilibrium, if disturbed, only when a vessel floats in still water. On a wave surface, 'stability,' or more correctly 'stiffness,' of a vessel tends to place the masts at right angles to the moving surface; but, as sufficient stiffness to maintain this position cannot be provided, the

usual result is that the ship rolls to a much greater angle than the wave surface. The question that Mr. Froude asked himself was this: 'What is the cumulative result of the continuous action of a series of consecutive waves operating on a given ship?' and he was successful in answering it by his theory of rolling, which is now generally accepted.

"The only cause of rolling which it is important to consider is the angular motion of the water or wave slope, and, as this extends to such a depth in ocean waves that even the largest vessels do not penetrate to a depth at which the motion is sensibly different from the surface motion, the vessel tends to place her masts normal to the wave surface.

"It is only by the successive impulses of several waves that large angles of rolling are attained, and when a ship encounters a system of waves, of a period equal to her own natural period of rolling in still water, the most dangerous condition is reached.

"Under these circumstances the angle of rolling will increase until, either the work taken up by resistance is equal to the work done on the ship per roll, or, failing this, she will turn over.

"To make a vessel steady, we can reduce the work the waves individually do on the ship by taking from the stiffness of the vessel. But if this has already been done, as far as is consistent with the other qualities required, the only method then available is to increase the resistance to rolling.

"The resistance due to a vessel's own form and surface depends on angular velocity, and is consequently very small for small angles of roll, and this is a defect which allows considerable rolling to be caused with a very small disturbing force, when this is isochronous with the vessel's natural period.

"By moving the centre of gravity of a ship a resistance may be obtained which is independent of angular velocity, and by so doing it is possible to balance the wave effort, and prevent angular motion, this being the most desirable course.

"The manner in which the controlling gear works will be better understood, if we imagine a vessel remaining upright among waves, while near the centre of gravity of the ship we place a short-period pendulum suspended so as to move with little friction; this will follow the change in the apparent direction of gravity without appreciable loss of time, so that any change in the wave angle and apparent direction of gravity cannot take place without due warning, which will indicate the time and amount of the disturbance. It is therefore only necessary to make the motion of the ballast bear some particular and constant ratio to the motion of this short-period pendulum to keep the balance true. The inertia of a heavy mass will cause some loss of time, as we can only use a limited force for its control, but it is possible to accelerate the phase of motion and overcome this difficulty, so far as to get good results.

"If now we imagine the ship to roll in still water, the effect of the combination just described will be to balance the ship's stability for a limited angle, but this defect is removed by the introduction of a second pendulum of long period which tends to move the ballast in the opposite direction to the first one, and enables the apparatus to discriminate between the angular motion of the water and that of the vessel.

"I find, however, that the long-period pendulum is rather a delicate instrument, and that its function can be served by a piston retarded by a cataract arranged so as to always slowly return the ballast to

the centre, and this device has the effect of accelerating the phase of motion, which, in some cases, we also require.

"We are therefore able, by very simple parts, to construct an apparatus which will indicate the direction and amount of motion necessary to be given to the ballast at a particular time so as to resist the wave: this power of indicating may be converted into one of controlling by suitable mechanism. The loss of time due to inertia of the necessary ballast is not always unfavourable when the apparatus has to extinguish rolling motion, the greatest effect being obtained when the ballast crosses the centre line of the ship at a time when it is most inclined to the water surface, and this corresponds to a quarter of the phase behind the motion of the short pendulum.

"In order to test the apparatus at sea, a tank for ballast was fitted under the cabin floors of the steam yacht 'Cecile'; this revolved about a shaft and was free to turn completely round the axis, which was inclined aft as much as the space available would permit.

"The motion of the ballast was controlled by a water cylinder having loaded valves in passages communicating between its two ends; these valves limited the resistance to motion offered by the water on the piston, which was connected to a crank on the shaft. This water cylinder was also available for giving motion to the ballast, and for that purpose it was fitted with a valve for distributing water under pressure. The mechanism for actuating this valve has already been referred to; care was taken to make it as prompt in action as possible, and it was found that no appreciable loss of time in the action of the gear occurred in this part of the apparatus.

"The first experiment made at sea was in rough weather; the yacht 'Cecile' left Shoreham harbour on March 10, 1891. There had been a severe gale and blizzard in the night, and the wind was still blowing hard; with sea on the port quarter the vessel rolled about 18° each way. After passing the Owers lightship the apparatus was started, and the effect was to reduce at once the angle of rolling to about 9°; and, in order to make sure that this was not due to changing the course of the vessel, a circle was turned, and it was found that the good result was maintained throughout.

"Various modifications of the apparatus were made, and the controlling gear was made more sensitive; but for action in bad weather it appeared that the gear was not improved by the alterations made. These alterations made the gear work in waves of reduced steepness, so that a small disturbance which would only cause a rolling motion of 2° or 3° was sufficient to put the gear in action.

"Examination of the automatic records proves that although the resistance to motion exerted by the moving ballast was only equal to about one-quarter the greatest turning moment due to the wave slope, this resistance was sufficient to reduce the rolling motion in a very satisfactory manner, and greatly increase the comfort afforded by the vessel. The rolling was usually reduced by the apparatus one-half, the vessel when disturbed by an unusually steep wave became steady much more quickly, and the feeling produced on board was, that that half of the motion which was deducted from the rolling was much the worst half."

APPENDIX V.

The Loss of the "Cobra" Torpedo-Boat Destroyer.

The finding of the Court Martial in the enquiry as to the cause of the loss of the "Cobra" was as follows:

"The Court, having considered the whole of the evidence before them, find that His Majesty's ship 'Cobra' foundered on the morning of the 18th day of September, 1901, while on passage from the Tyne to Portsmouth. The Court has come to the conclusion that His Majesty's ship 'Cobra' did not touch the ground nor meet with any obstruction, nor was her loss due to any error in navigation, but was due to structural weakness of the ship. The Court also find that the 'Cobra' was weaker than other destroyers, and in view of that fact it is to be regretted she was purchased into His Majesty's service."

The race for high speeds has resulted in a grave disaster.

How the race has progressed may be stated briefly.

	Builder.	Year.	Speed. Miles an hour.
First torpedo boat for Norway	Thornycroft	1873	17¼
Second, for Sweden...........	Thornycroft	1875	17¼
Third, for Denmark.........	Thornycroft	1875	18

In 1876, boats were built in England for the French navy of 18 knots.

In 1877, the first torpedo boat for the British navy was built at Chiswick with a speed of 18½ knots.

In 1878, Messrs. Yarrow of Poplar raised the record to 21.93 knots; in 1880, to 22.16 knots and in 1885, to 25.1 knots per hour.

In 1887, the "Ariete," which was fitted with water-tube boilers, was built at Chiswick and attained a speed of 26 knots.

In 1893, the record was again beaten by Mr. Yarrow with a speed of 27.31 knots. The subsequent steps were as follows:

Builder.	Vessel.	Date.	Speed in knots.
Yarrow	"Hornet".......	1893	27.31
Thornycroft...	"Daring".......	1893	29.27 Light draft.
Thornycroft...	"Boxer"........	1895	29.31
Yarrow	"Sokol"........	1895	29.77
Normand......	"Forban".......	1895	31.029
Thornycroft...	"Desperate"....	1896	31.034
Thornycroft...	"Albatross".....	1898	32.3
Parsons.......	"Viper"........	1899	35.5

The credit of the ships built on the Thames has hitherto been unquestioned. Their record in this respect is supported by the following:

The Loss of the "Cobra."

To the Editor of the *Times*:

Sir.—May I be permitted to endeavour to remove the want of confidence which is felt just now, due to recent events, by naval officers and the public, touch-

ing the seaworthiness of vessels of the torpedo boat type (which includes destroyers)?

The following is a short statement of the number of vessels of this class, varying from 100 ft. to 220 ft. in length, which we have constructed, and which have navigated long distances without showing the slightest symptom of structural weakness:—Thirteen navigated to Buenos Ayres; 11 to Pola; four to Rio de Janeiro; two to Valparaiso; one to China; five to Holland; two to the Dutch East Indies; one to Ecuador (via Cape Horn); six to Greece; five to Italy; six to Japan; one to the Black Sea; one to St. Petersburg; and one to Australia. Total 59.

I may add that we make a practice of insuring our vessels until they are handed over, which sometimes includes delivery at distant ports, and we have never had occasion to make a claim on the underwriters either due to structural weakness or breakdown of machinery.

I remain, Sir,
Yours truly,
A. F. Yarrow,

Isle of Dogs, Poplar, E., Oct. 21.

The Loss of the "Cobra."

To the Editor of the *Times*:

Sir.—The question which has been raised at the "Cobra" Court-Martial, as to whether 30-knot torpedo-boat destroyers can be anything but fair-weather boats, leads me to write you upon an experience which I had recently. I was a guest on the Imperial Japanese fleet, crossing from Chemulpho to Chifu (in the

middle of this year). The fleet consisted of two battleships, three large armoured cruisers, one smaller armoured cruiser, and two destroyers. I was able from the "Asama," armoured cruiser of 9,800 tons, to watch the action of the destroyers in rough weather. We encountered a typhoon about six hours out and had most terrible weather. So bad was the storm that no merchant vessels would venture out of harbour, even new steamers of 2,000 to 3,000 tons losing several days rather than risk the force of the waves. The "Asama" pitched and rolled abnormally—on more than one occasion rolling to 13 degrees. The two destroyers were both fast boats, one of 32 knots, the other of 30 knots speed respectively. They were built on the Thames, at Thornycroft's and Yarrow's yards. Naturally they were affected greatly by the weather and pitched and rolled tremendously. They suffered no material harm, however, and arrived safely at Chifu; from here they were able to proceed to Ta-Ku six hours later.

Speaking with one of the officers who had brought one of the destroyers out from England, he informed me that the boat came out alone, unaccompanied by a larger vessel. The voyage lasted 5½ months and much bad weather was encountered. There were no mishaps, however, and no breakages all through the voyage.

It may be said that isolated cases prove nothing, but it is of interest to know that British-built fast torpedo-boat destroyers can pass successfully and unharmed even in the roughest weather, manned in these cases by Japanese, not British, sailors. Thanking you in advance,

I am yours truly,

Alfred Stead.

14 Norfolk Street, W. C., Oct. 16.

The finding of the Court Martial will doubtless be followed by a Report to Parliament and that may be confidently expected to re-establish the credit of the Destroyers either by showing that the ruptures and buckling which have occurred are due to preventable causes, apart from the actual thicknesses of material employed, or else by the introduction of such strengthening as may be desirable in vessels which have been built with insufficient care.

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(NOTE.—The affix B signifies British Ship-of-War.
" F " French "
" G " German "
" I " Italian "
" R " Russian "
" U.S " United States ")

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